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## The Roman Aqueduct Across the Gard River, Near Nimes, France.

By LOUIS A. ROBB.*

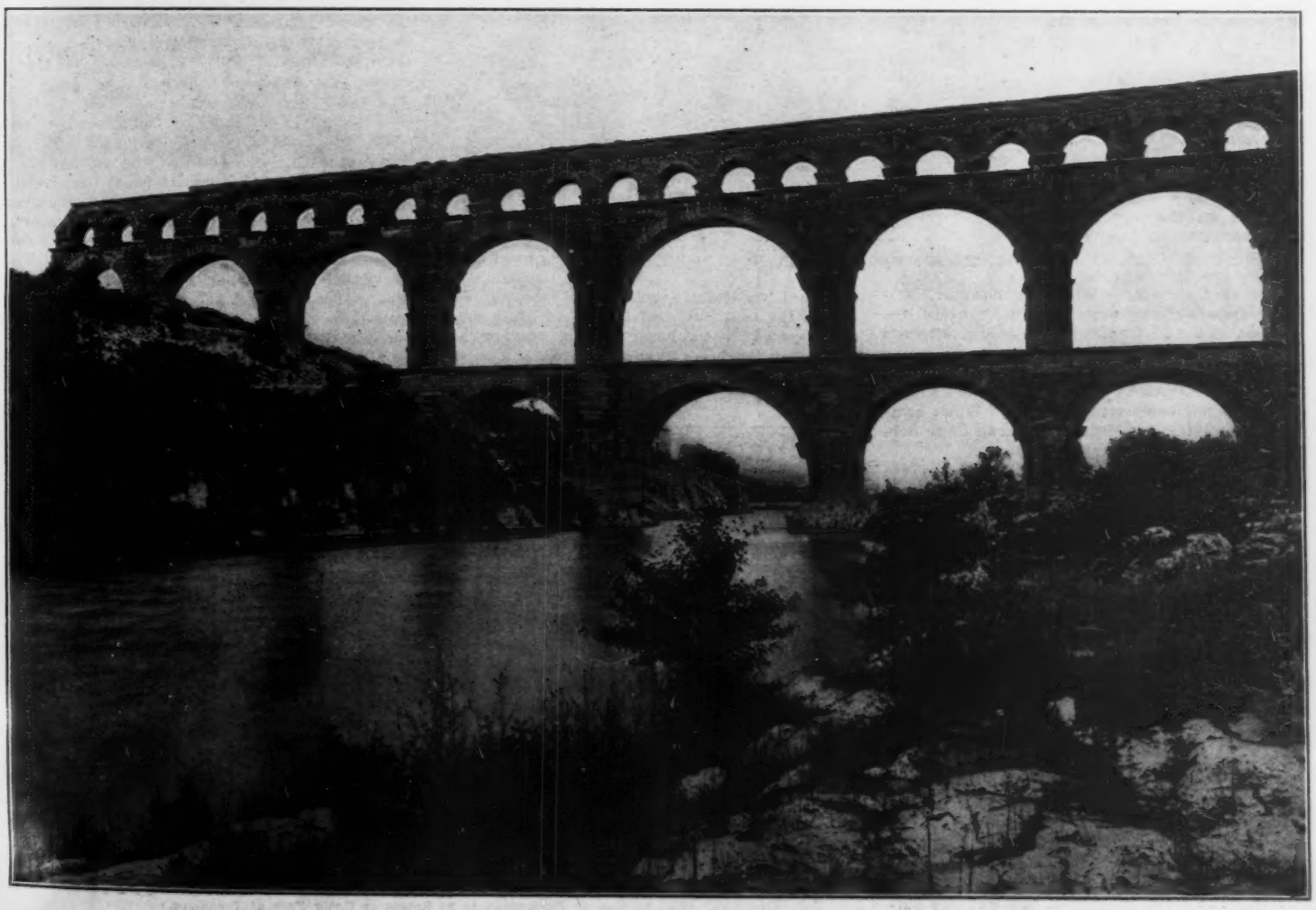
That the Romans were masters of the art of masonry construction is matter of common knowledge; but perhaps it is not quite so well known that many of the finest examples which remain to us of their skill in this direction are not in Rome or anywhere in Italy, but in Provence. The Pont du Gard is a monument to their skill which the writer found by far the most impressive of the many which he saw during a recent tour of that region. It is a portion of an aqueduct, the total length of which was about 25 miles, and which was built about 15 B. C. to bring spring water from the hills to the baths of Nemausus, a Roman town on the site of the present city of Nimes.

The Pont du Gard carries the aqueduct across the River Gard near the town of Remoulins. It consists of three tiers of arches, six arches in the lowest tier, eleven in the second and 35 in the highest. The structure as it stands to-day is about 880 ft. long and at the lowest point of the valley about 160 ft. high. The three stories are of decreasing width from the bottom up, the lowest tier of the arches being about 25 ft. wide and the highest about 11 ft.

The finest stone masonry left by the Romans is almost always found to be laid without mortar, and the Pont du Gard is no exception. From ground level to the waterway on top there is not a trace of mortar in piers or arches. Cement was used, however, for lining the conduit, and this seems to be as hard to-day as it was 1,900 years ago. The channel is about 5 × 2 ft. 6 ins. and is covered with flat stones which measure 12 × 3 ft. × 14 ins.

The aqueduct was badly damaged in the 16th century, when the piers of the second story were cut away for about one-third of their width in order to convert the lowest story into a highway bridge for military purposes. The damage was afterwards repaired, and about 1745 was built the present highway bridge, which is of the same elevation and span length as the lower tier of aqueduct arches. This highway is on the far side of the bridge, as shown in the accompanying view.


*71 Lincoln Park, Newark, N. J.

PONT DU GARD AQUEDUCT BUILT B.C. 15 BY THE ROMANS NEAR NIMES, FRANCE.

FIG. 1. VIEW OF PARTIALLY COMPLETED OIL RESERVOIR NO. 1. SAN LUIS OBISPO, CAL.

## The Partial Failure of a Large Concrete Oil Reservoir at San Luis Obispo, Cal.

During the past summer the Producers' Transportation Co., a company controlling the storage and delivery of large quantities of oil in Southern California, has had built at San Luis Obispo, Cal., two exceptionally large concrete tanks or, more properly, reservoirs, in connection with the large so-called "tank farm" at that place. This "farm" is some ten miles from Port Hartford, Cal., one of the largest oil shipping ports in the world. It has been found that the steamer facilities are often insufficient to care for the oil pumped through pipe lines from the various fields, so the San Luis Obispo tanks have been provided for storage, intermediate between the fields and the steamers. The two large concrete reservoirs, each holding about 1,000,000 barrels of oil, were put in service late this fall. Oil was started into the first one on Nov. 1, 1910, and was pumped in continuously until Nov. 21, when a portion of the side wall of the reservoir collapsed, letting a large quantity of the contained oil escape into the moat formed by the surrounding earth fire-walls.

On account of the lack of storage facilities wherein to pump the oil held in by these fire-walls, it has been impossible as yet to lower the level of the oil sufficiently to determine definitely the nature of the collapse. Furthermore, there is prospect of litigation regarding the responsibility for the accident, so that there is a great reluctance on the part of those in authority to give out any information concerning the failure or the design of the tanks. We have, however, procured from various sources an account of the collapse, and a description of the design, which is accurate so far as it goes, and which will serve as a preliminary statement to inform engineers of certain features of the tank and its collapse that have not heretofore appeared. When complete information is available we hope to be able to present a fuller account.

The two tanks built at San Luis Obispo are alike in design and construction, but the one that partially failed will be described here. This reservoir consists of a reinforced-concrete circular wall, of inverted T-section, 601 ft. in. diameter, enclosing an area of some 6½ acres, paved with a concrete floor reinforced with wire mesh.

The floor is lowest at the center, where the draw-off sump is located, and rises 3 ft. from that point to the circumference. The wall is 20 ft. 4 inches higher than the floor level at the wall, so that the reservoir will hold about 1,000,000 barrels of oil, assuming 5⅓ cu. ft. to each barrel.

The accompanying cut (Fig. 2) shows an approximate section through the side wall. This drawing is not the official or authorized section, but is a sketch made up from notes taken by several engineers who examined the work during construction. In some details, then, it may not be accurate, but in the main it is undoubtedly correct. The main outlines of the wall are sufficiently well shown as not to require further explanation, but the details of the reinforcement and of the "subfooting" at the heel of the base are not quite so clear.

The reinforcement, as given in the cut, is placed as found by our representative during the construction. Whether this was constant for the whole wall we cannot state. It will be noticed that the main reinforcement in the vertical wall

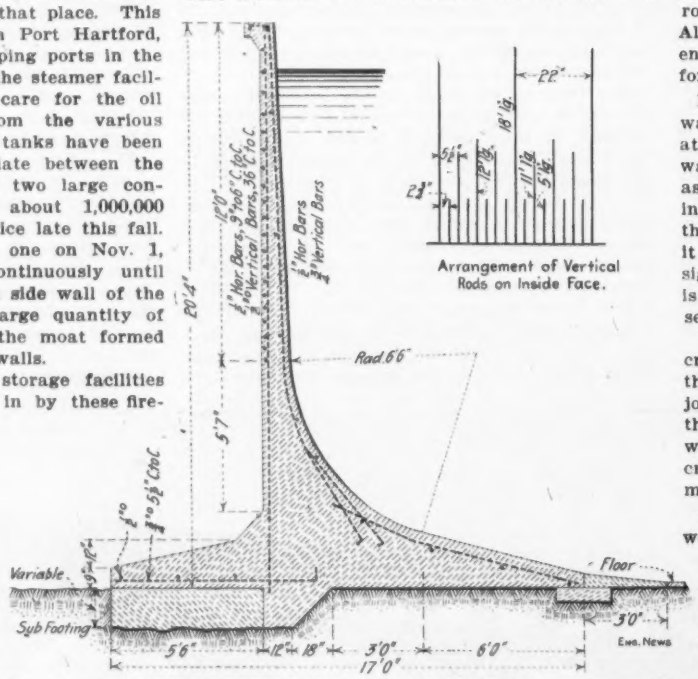



FIG. 2. APPROXIMATE SECTION THROUGH WALL OF RESERVOIR.

is placed vertically about 1 in. from the inner face of the wall and consists of ¾-in. plain round rods, spaced 2¾-in. apart at the bottom and varying in height so that at the top of the wall the spacing is 22 ins. These are bound together by ½-in. horizontal rods, which were originally intended to be spaced 12 ins. c. to c., but which appear to have been placed about 48 ins. c. to c. The vertical rods bend down into the curved inner face of the wall and are anchored there by a bend, and the reinforcement is continued by rods parallel to the sloped upper face of the toe wall. In the outside face of the wall the vertical rods are spaced 36 ins. c. to c., and the horizontal rods 9 ins. at the top and 6 ins. at the bottom. All horizontal rods were tied together by looped ends. The base of the wall is additionally reinforced at the heel.

In the middle of the base a shallow cut-off wall is provided for the whole circumference, and at certain places, where the foundation ground was considered doubtful, an additional subfooting, as shown, was provided. This subfooting varied in depth with the condition of the ground, and there is a difference of opinion as to whether it was carried to the depth required by the designer in all places. Upon this question there is a controversy which is one of the points to be settled in the expected litigation.

The paving consists of a 2½-in. layer of concrete, reinforced with wire mesh, extending over the entire floor area, with a ½-in. expansion joint, filled with tar paper, between the wall and the floor. The reservoir was covered with a wooden roof, resting on timber posts set on concrete pedestals. It has a 1:12 slope, making the middle post some 48 ft. high.

In the construction, the floor and the wall were both laid on the clay bottom, which had previously been tamped, but not otherwise strengthened. A section of the footing course of the wall was then laid to about the elevation of the curve, and filled (Fig. 2), then the upper reinforcement and forms placed and the wall for the section under construction finished in a two-days' run. The lengths of these sections were governed by the capacity of the concrete plant. Floor concrete was a 1:7 mix, and the wall concrete 1:5. Several thousand yards of material was excavated in leveling the site, before the floor was laid, and the earth banked up behind the concrete wall to act as a retaining wall in

FIG. 3. WALL OF RESERVOIR NO. 1 UNDER CONSTRUCTION.
(Mat of Rods in Foreground to be Raised to Upper Face of Toe Slope.)

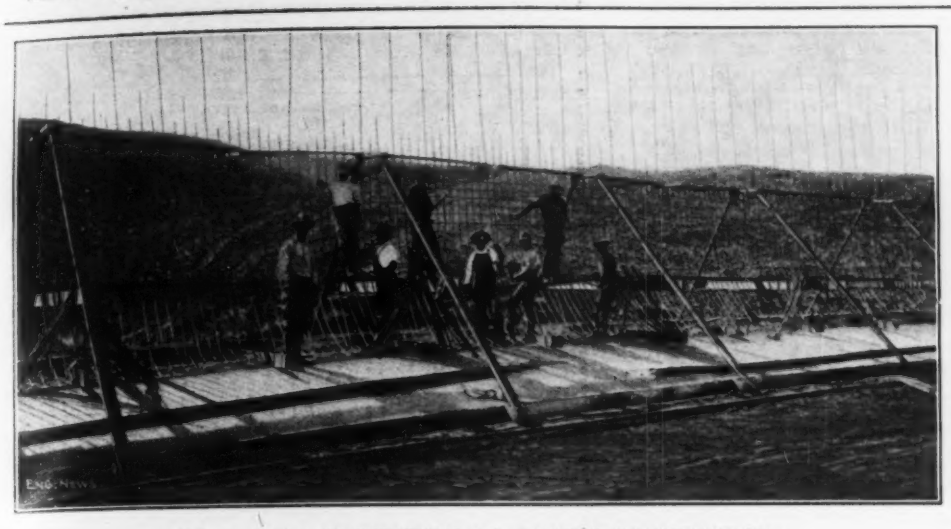


FIG. 4. WALL OF RESERVOIR NO. 2 UNDER CONSTRUCTION.

case of a break and also as a fire guard against the grass fires which sometimes occur in this vicinity.

The two reservoirs were not built simultaneously, but No. 1 was well along in construction before No. 2 was started. Reservoir No. 1 was completed in the latter part of October, and on Nov. 1, filling was started by pumping oil, at an average temperature of 95° F., direct from the fields. After filling had been going on for about a week, numerous leaks were observed through the concrete of the wall, first appearing as seepages, and later developing into spurts as the head increased. At the same time a leak was noticed under the wall at a place where the subsoil had been weakest, and where additional depth had been given the subfooting. It is reported that there was a difference of opinion between the engineers as to the depth to which this footing should be carried, and that the wall as built (with a subfooting about 18 ins. deep), was not founded as deep as was desired by the more cautious of the staff. At any rate efforts were made to stop the leaks with poor success, and finally on Nov. 21, when there was about 900,000 barrels of oil in the tank (oil level about 18½ ft. above the floor), the collapse occurred.

According to our information the upper section of the wall for a distance of about 20 ft. first fell inwards, breaking off through the vertical section, and the oil, rushing out through the break, tore completely out a section some 125 ft. long. This section separated into two separate pieces, which completely overturned, beside the fragments hanging to the standing wall ends. The oil was not lost, but was retained by the high earth embankment built around the entire wall. Fig. 5 shows two views of the break, taken some two weeks after the accident, when the oil level had lowered slightly. The position that the vertical wall took is sketched in Fig. 6 and that position may be understood by an examination of Fig. 5. The sloping upper face of the toe slope is on the side away from the reservoir, and the facing joint between the toe and the floor is the upper edge of the broken sections rising out of the oil.

It was at first reported that the section destroyed was the oldest in the circumferential wall. This is denied by the designer of the wall. We have it on good authority that there were sections of the wall put in at least two weeks after the one that failed. Just how old was the newest concrete, or in fact that concrete that failed, we have not been able to ascertain, beyond the statement that "the forms were barely off when oil was turned into the reservoir."

Any cause assigned for the failure is based on the information given above. Until further information regarding age and condition of concrete, and nature of the footings is at hand, it must be surmised that the combination of a concrete wall section weakened by percolation and an undermined footing is responsible. The possible effect of a heated oil upon the concrete should also be taken into consideration. It seems probable that the main wall was weakened by the leaks and at the same location the base of the wall was undermined. This dropped the toe of the base and broke off the upper portion of the wall, and the subsequent rush of oil would easily explain the further collapse.

Reservoir No. 2 now contains about 450,000 barrels of oil and seems to be standing without leak or undermining. The reservoirs were built at a contract price of $165,000 each, by the Weber-Duller Co., and were designed by Mr. Carl Weber of Los Angeles, Cal. It should perhaps be stated that the work was a rush job, only 100 days being allowed for the construction of the two reservoirs. This necessitated a very large force of men, as may be noted from the view shown in Fig. 1.

EXPERIMENTS WITH "WATER-FINDERS" were described by Prof. J. Wertheimer, University of Bristol, England, in a paper read recently before the Royal Society of Arts and published in our London contemporary, "The Surveyor," for Feb. 24, 1911. Prof. Wertheimer gave several water-finders opportunity to locate water in a well and water flowing in pipes, the actual location being known to him but not to the finders. The results of the tests are shown in diagrammatical tabular form, combined with explanatory notes, and the relation of some humorous incidents. We quote the concluding paragraph of the paper, as follows:

Since these experiments were undertaken I have received a large amount of correspondence and many publications in regard to dowsing in this country and abroad, but I have not been able to find any experienced dowser willing to submit to definite experiments, nor have I been able to induce the proprietors or agents for any of the instruments for finding water to submit these to a scientific test.

My opinion is that the motion of the dowser's rod and the sensations which he experiences are not due to any cause outside himself. On the other hand, I believe that when the dowsers with whom I experimented stated that they did not cause the rod to move, they were saying what they believed to be the truth, but were unconsciously misleading themselves.

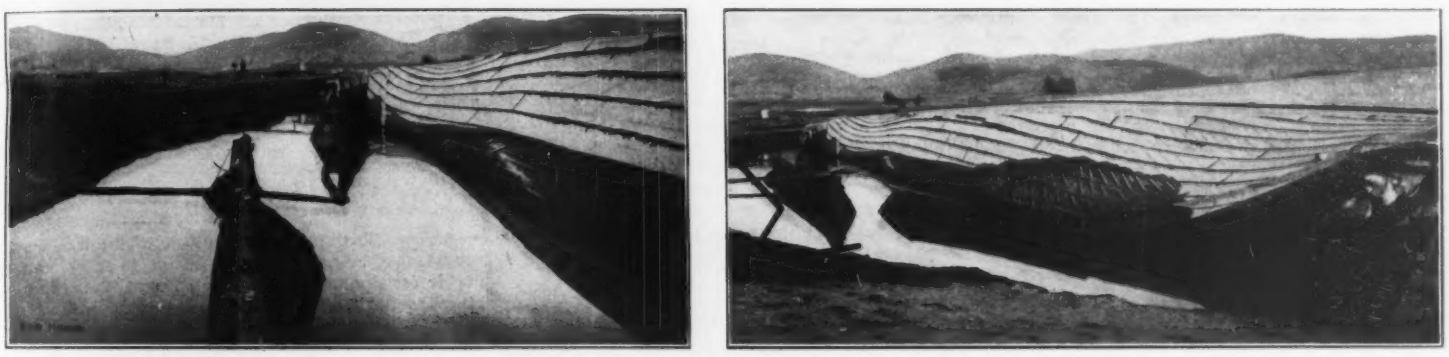


FIG. 5. TWO VIEWS OF BROKEN SECTION OF WALL.
(Taken Dec. 7, 1910.)

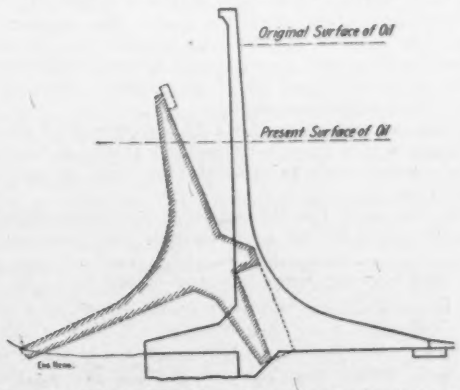



Fig. 6. Sketch Showing Approximate Position of Portion of Wall Which Was Overturned.

## A Method for Determining the Parts Per Million of Dissolved Oxygen Consumed by Sewage and Sewage Effluents: Columbus Sewage Works.

By C. B. HOOVER.[1]

The analytical methods usually employed to show the degree of purification effected by sewage treatment do not reveal quantitatively the relative stability of the dissolved and suspended matter and hence are not reliable indices of the deoxygenating properly of sewage or sewage effluent. To meet this deficiency a method has been in daily use at the Columbus Sewage Works since March 1, 1910, which has as its purpose the determination of the deoxygenating effect of the discharge of raw sewage and sewage effluents into a stream of water. The method of procedure is described herein.

First Step: Determine the oxygen in parts per million consumed from potassium permanganate for the raw sewage and various effluents according as follows, using reagents of the concentration specified in "Standard Methods."

Take a volume of the sample sufficient to consume not less than 5 c. c. nor more than 10 c. c. of potassium permanganate and make up to 100 c. c. with distilled water. Add 5 c. c. of 1.1 sulphuric acid, then enough permanganate from a burette to give a pink color which persists for a few moments (more than 2 c. c. is rarely

[1]Chemist-in-Charge Sewage Purification Works, Columbus, Ohio.

TABLE I.—RESULTS SHOWING THE PURIFICATION OF SEWAGE AS INDICATED BY THE PARTS PER MILLION OF OXYGEN CONSUMED, 1ST, AS DISSOLVED OXYGEN AND 2D, FROM POTASSIUM PERMANGANATE: SEWAGE PURIFICATION WORKS, COLUMBUS, OHIO.

| | Mean Monthly Values, Year, 1910 | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crude sewage | | | | | | | Septic effluent | | | | | | | Filter effluent | | | | | |
| | | Dissolved oxygen | | | | | | | Dissolved oxygen | | | | | | | Dissolved oxygen | | | | |
| Month. | Dilution: One volume of sample to volumes of distilled water | Initial | Residual | Consumed | Consumed by undiluted sample | Oxygen consumed from potassium permanganate | Ratio: Permanganate value to dissolved oxygen value | Dilution: One volume of sample to volumes of distilled water | Initial | Residual | Consumed | Consumed by undiluted sample | Oxygen consumed from potassium permanganate | Ratio: Permanganate value to dissolved oxygen value. | Dilution: One volume of sample to volumes of distilled water. | Initial | Residual | Consumed | Consumed by undiluted sample | Oxygen consumed from potassium permanganate | Ratio: Permanganate value to dissolved oxygen value |
| | | | | | | | 1: | | | | | | | 1: | | | | | | | 1: |
| March | 18 | 9.0 | 4.4 | 4.6 | 87 | 32 | 2.72 | 14 | 8.7 | 3.5 | 5.2 | 78 | 26 | 3.00 | 1.9 | 9.4 | 4.2 | 5.3 | 15.4 | 10.8 | 1.42 |
| April | 29 | 9.0 | 4.5 | 4.5 | 135 | 52 | 2.59 | 18 | 8.9 | 3.9 | 5.0 | 95 | 31 | 3.06 | 2.8 | 9.3 | 4.0 | 5.3 | 20 | 13 | 1.54 |
| May | 23 | 9.2 | 4.4 | 4.8 | 115 | 43 | 2.67 | 15 | 9.1 | 4.3 | 4.8 | 77 | 20 | 3.85 | 5.0 | 9.4 | 4.8 | 4.6 | 28 | 23 | 1.22 |
| June | 22 | 8.1 | 3.3 | 4.8 | 110 | 44 | 2.50 | 15 | 8.0 | 3.2 | 4.8 | 77 | 26 | 2.96 | 2.9 | 8.4 | 3.7 | 4.7 | 18 | 15 | 1.20 |
| July | 22 | 7.6 | 2.7 | 4.9 | 113 | 47 | 2.40 | 18 | 7.6 | 2.8 | 4.8 | 91 | 32 | 2.84 | 3.3 | 7.5 | 2.6 | 4.9 | 21 | 19 | 1.10 |
| August | 24 | 7.6 | 2.2 | 5.4 | 135 | 50 | 2.70 | 24 | 7.7 | 2.5 | 5.2 | 130 | 42 | 3.10 | 5.5 | 7.8 | 1.5 | 6.3 | 41 | 25 | 1.64 |
| Sept | 25 | 8.6 | 3.1 | 5.5 | 143 | 47 | 3.04 | 24 | 8.6 | 4.0 | 4.6 | 115 | 38 | 3.03 | 4.1 | 9.0 | 3.9 | 5.1 | 26 | 17 | 1.53 |
| Oct | 21 | 9.3 | 5.0 | 4.3 | 95 | 46 | 2.06 | 16 | 8.7 | 5.1 | 3.6 | 61 | 29 | 2.10 | 4.3 | 9.5 | 5.4 | 4.1 | 22 | 18 | 1.22 |
| Nov | 25 | 8.9 | 4.2 | 4.7 | 122 | 66 | 1.85 | 16 | 8.8 | 4.4 | 4.4 | 75 | 41 | 1.85 | 4.8 | 9.1 | 3.9 | 5.2 | 30 | 27 | 1.11 |
| Dec | 23 | 9.2 | 3.8 | 5.4 | 130 | 60 | 2.17 | 14 | 9.2 | 4.1 | 5.1 | 77 | 37 | 2.08 | 5.0 | 9.3 | 3.8 | 5.4 | 32 | 24 | 1.33 |
| Means | 23 | 8.6 | 3.7 | 4.9 | 118 | 49 | 2.40 | 17 | 8.5 | 3.8 | 4.7 | 85 | 32 | 2.66 | 4.0 | 8.9 | 3.8 | 5.1 | 25.5 | 19 | 1.34 |

needed). Place on gauze over a flame and from time to time during the period of digestion, as the color begins to disappear, add just enough permanganate from the same burette to preserve a pink color. Continue in this way until the sample has been boiled five minutes, then proceed in the customary manner. Calculation of result: Total c. c.'s of permanganate, minus blank of 0.3, minus c. c.'s of oxalate, × 100, divided by c. c.'s of sample, equals the parts per million of oxygen consumed.[2]

Second Step: The oxygen in parts per million consumed as dissolved oxygen is determined by: (1) making a proper dilution of the sample with distilled water and mixing well; (2) determining the initial dissolved oxygen in the mixture; (3) incubating the mixture in a sealed glass-stoppered bottle for 24 hours at 37° C.; (4) determining the residual dissolved oxygen after incubation; and (5) calculating the parts per million of dissolved oxygen consumed by multiplying the difference between the initial and residual values by the dilution.

Detailed Procedure: The dilution required is estimated from previous permanganate and dissolved-oxygen values. Suppose, for instance, that on a previous determination a raw sewage showed 70 parts of oxygen consumed from potassium permanganate and 175 parts of oxygen consumed as dissolved oxygen, then the ratio existing between the two values is 1 to 2.5. If these results were secured yesterday and to-day the sewage shows a permanganate value of 80 parts, then the approximate dissolved oxygen value will be 80 × 2.5, or 200. It is the practice in this laboratory to make the dilution such that about five parts of dissolved oxygen in the mixture will be consumed during the period of incubation. Using five parts as the standard, the approximated dissolved oxygen value of 200 is divided by 5, which gives 40 as the probable dilution required. One part of the sewage and 39 parts of distilled water are then well mixed and two portions immediately withdrawn. The initial dissolved oxygen is determined at once on one portion and the other portion is placed in the incubator in a sealed (with paraffin) glass stoppered bottle. At the end of 24 hours the residual dissolved oxygen is determined on the incubated sample and the parts per million consumed is calculated as stated above.[3]

The mixing is accomplished as follows: 700 c. c. of distilled water is poured into a 1,000-c. c. salt mouth glass stoppered bottle and the proper volume of sample added. They are then well mixed by shaking, after which two 300-c. c. glass stoppered bottles are immediately filled by pouring carefully so as to avoid increased aeration. The first bottle filled is sealed with paraffin and incubated, while upon the second, the dissolved oxygen is immediately determined.

The incubated samples are sealed in order to eliminate absorption from the air as a variable. The following table of results is a comparison of methods of incubation as shown by (1) the dissolved oxygen present after the period of incubation, and (2) the mean per cent. that results of triplicate determinations will vary from the mean result.

| | Dissolved oxygen after incubation, parts per million. | Mean per cent. variation from mean value. |
|---|---|---|
| Glass-stoppered bottle sealed with paraffin | 1.9 | 14 |
| Glass-stoppered bottle not sealed | 3.1 | 24 |
| Open bottle | 4.6 | 3 |

With the open and glass-stoppered bottles not air tight, it is impossible to determine how much oxygen has been consumed. Absorption from the air, as indicated in the above table, is seen to be quite a factor in such work and consequently the desirability of eliminating it is apparent. The studies carried out in this laboratory indicate that absorption from the air in unsealed bottles is most pronounced in those samples which carry the most oxidizable matter.

The reason for fixing upon five parts as the amount of dissolved oxygen to be consumed during the period of incubation, is that from two to four parts of dissolved oxygen will remain in the sample after incubation and in the presence of this amount of dissolved oxygen the other sources of oxygen (nitrites and nitrates) will not be drawn upon and all of the oxygen consumed will be dissolved oxygen.

The accompanying Table I. is a record of the results which have been secured at the Columbus Sewage Works through the use of this methods.

In the table the differences in the purification as indicated by the permanganate and dissolved oxygen values are rather striking and the gist of the whole matter is to be found therein. The contention is that the results of the permanganate test and all the other customary analyses do not give values which approximate the actual purification accomplished from the standpoint of probable nuisance production in a stream of water. An inspection of this table will show that the degree of purification as indicated by the permanganate and dissolved oxygen values is as follows:

TABLE II.—SUMMARY OF ABOVE DATA.

| | Dilution: One volume of sample to volumes of distilled water. | Dissolved oxygen: Initial. | Dissolved oxygen: Residual. | Dissolved oxygen: Consumed. | Consumed by undiluted sample. | Oxygen consumed from potassium permanganate. | Ratio: Permanganate value to dissolved oxygen value. |
|---|---|---|---|---|---|---|---|
| Crude sewage | 23 | 8.6 | 3.7 | 4.9 | 118 | 49 | 1 : 2.40 |
| Septic eff | 17 | 8.5 | 3.8 | 4.7 | 85 | 32 | 1 : 2.66 |
| Filter eff | 4 | 8.9 | 3.8 | 5.1 | 25.5 | 19 | 1 : 1.34 |

| | Percentage purification as indicated by | |
|---|---|---|
| Purification effected by: | Permanganate values. | Dissolved oxygen values. |
| Septic tanks alone | 35 | 28 |
| Sprinkling filters alone | 41 | 70 |
| Septic tanks & sprinkling filters | 61 | 78 |

The settling basins will effect about 20% improvement over the value given in the above table for the sprinkling filter effluent, thus bringing the purification by the whole system for the year 1910, as indicated by the deoxygenating property of the raw sewage and final effluent, to 83%.

Improvements in the preliminary treatment, which are being contemplated and which will conform to the recent advances along this line, will result in the production of a better septic tank effluent and also improve the work of the sprinkling filters, which, however, has been uniformly good.

During the year 1910 the septic tanks removed 60% of the total suspended matter from the raw sewage, but the absorption of sludge decomposition products by the liquor as it flowed through the tanks, resulted in an actual purification of only 28% as indicated by the deoxygenating effect which such liquor would have on a stream of water.

The improvements in the preliminary tank treatment are to be of such a nature that the liquor flowing in the tanks will be protected from these decomposition products and consequently the tank effluent will have a lower deoxygenating coefficient.

The Columbus Sewage Works is able to maintain the production of an effluent, the quality of which is such that a small sluggish stream, having a flow during warm-weather low-water conditions between 20 and 25 million gallons per 24 hours, is able to maintain a small reserve of dissolved oxygen and to remain inodorous.

[2]A 300-c. c. Erlenmeyer flask is well adapted to this determination. If more acid is used, larger volumes of sample may be taken and a correspondingly larger blank should be deducted.

Mass action exercises a striking effect on the oxidation when all of the permanganate is added initially, as is the custom in making this determination. This fact is indicated by the following results:

OXYGEN CONSUMED FROM POTASSIUM PERMANGANATE BY A SEWAGE EFFLUENT.

8.5 c. c. of permanganate consumed as per method outlined above.

12.1 c. c. of permanganate consumed when 15 c. c. of permanganate was added at start.

14.22 c. c. of permanganate consumed when 20 c. c. of permanganate was added.

In the above results, the second value is 42% higher and the third value 67% higher than the first. If this sample had been sent to two different laboratories for analysis, the first might have reported the 12.1 value, while the other reported the 14.2 value, or, the differences reported might have been much greater. Where sewage analysis is a part of the routine, the values secured from day to day in this determination are not comparable because the usual method of conducting this analysis is not conducive to such results. The method outlined above gives values which are strictly comparable as to the relative concentration or strength of the samples dealt with from day to day.

[3]The laboratory record is kept as follows:

| Date. | Source. | Parts of distilled water. | Parts, sample. | Parts per million: Dissolved oxygen. Initial. | Residual. | Consumed. | Consumed by undiluted sample. | Oxygen consumed from potassium permanganate. | Ratio: permanganate value to dissolved oxygen value. |
|---|---|---|---|---|---|---|---|---|---|
| Dec. 20 | Crude sewage | 29 | 1 | 9.4 | 4.0 | 5.4 | 162 | 67 | 1:2.4 |
| Dec. 28 | Crude sewage | 20 | 1 | 8.3 | 3.1 | 5.2 | 100 | 60 | 1:1.8 |
| Dec. 29 | Crude sewage | 9 | 1 | 9.3 | 3.5 | 5.8 | 58 | 27 | 1:2.1 |

# An Emergency Rope Drive in a Hydroelectric Plant.

By H. R. LEE.*

At Holcomb's Rock, Va., the Virginia Electrolytic Co. operates a hydroelectric power plant for its smelting and electrolytic work. The company has been occupied for some time with the manufacture of ferro-silicon, with the production of sodium from a fused electrolyte, and with experimental electrolytic work of a similar nature. This corporation controls the entire flow of the James River at Holcomb's Rock. It can rely on a minimum flow of 1,440 cu. ft. per sec. from January to July, inclusive. During the months of August to December the flow varies below the figure stated, being 720 cu. ft. per sec. for the greater part of the period, rarely lower. The first figure corresponds to the operation of the six main turbines at a head of from 17 to 18 ft. With the latter flow only half of that number of turbines can be operated.

The general arrangement of this power plant was described and illustrated in Engineering News, April 14, 1898, by the Constructing Engineer, Mr. John C. Temple, M. Am. Soc. C. E. As additions have been made since that date, both to the turbine and generator equipment, the writer has felt justified in giving a brief description of the plant. Fig. 1 shows the station in emergency form, but the usual arrangement can be understood by noting that the centers of the six inclined rope-drives are usually in one plane. Generators Nos. 1 and 4 only are shown as displaced.

Experience with the river flow has led to the division of generators into equal groups of alternating and direct-current machines. The six turbines are all alike and are of a twin horizontal type with 39-in. runners. The three alternators are similar, though not all of one company's make. Each has a rating of 300 KVA., 110 volts, 2,720 amps. The usual output, however, is only 188 KW. or 252 HP., due to the unfavorable turbine setting, and to losses in the rope drive and generator. It is considered advantageous, however, to use such generators, of a size apparently unwarranted, on account of a wider range of voltage and current for experimental work.

The three direct-current generators are of a special type, designed for this plant. They possess the feature, now common, of two commutators, one on each side of the armature. Each commutator derives its current from an independent portion of the armature winding, and the equal division of the current output, over the two commutators, is effected by relative brush-rocker positions. These generators are shunt-wound and usually self-excited. They are rated to give 2,500 amps., at 100 volts, corresponding to 250 KW., or 335 HP. Here again, for the exigencies of electrolytic experiment, excessive electrical capacity has proven valuable, as the generators have been operated on commercial work at 134 volts and 1,400 amps., and, experimentally, at 11 volts and 2,500 amps. These extremes have been attained with self-excitation, and only below 50 volts is it deemed necessary to shift the position of the brush-rockers to secure sparkless commutation.

In the year 1910, the dry season was later than usual, and the experimental work in electrolysis was prosecuted until Sept. 10. At that date an order was received to cease the work, and to divert the entire river-flow to turbines Nos. 1, 2 and 3, driving the alternators of corresponding numbers, which furnish 750 HP. to the ferro-silicon furnace. It was intended that the plant should manufacture ferro-silicon only until Jan. 1, 1911. This policy fixed, the Resident Manager left the plant for an extended tour, leaving the writer in charge. On the next day, Sept. 11, the main shaft of turbine No. 1 parted between the runners disabling that unit which represented one-third of the capacity of the plant at the time.

It was seen to be useless to attempt to move the alternator of the disabled unit down the generator room, and there to connect it to one of the three turbines driving the idle direct-current generators, for this meant the erection of about 1,000 lbs. of copper cables and bars. The time required for such work would have taken three weeks even had the copper been in stock. From Fig. 1, it is seen that the current is carried over the forebay to the furnace house at the generator potentials. This requires two groups of four 1-in. copper cables from each generator to the paralleling bus-bars in the furnace house. These cables weigh 17.3 lbs. per running foot, and are supported by suspension bridges. The furnace-house bus bars are of ½ × 5 in. copper bars. Each of the two lines of bars are of single, double or triple bar according to the location of the contributing feeders, in order to carry 7,500 amps. finally, the sum of the currents from the three alternators.

The arrangement adopted may be understood from the accompanying figures. Fig. 1 shows a plan and section; Fig. 2 shows a view of the generating room from the alternating-current end, and Fig. 3 from the direct-current end. We decided that if the alternator could not be moved to the turbine No. 4, replacing for a time the direct-current generator of that number, then the power of one of the idle turbines must be brought to the alternator. The nearest direct-current generator, No. 4, was converted into a motor, driven by current from No. 5, and the power was transmitted 48 ft. along the main walkway of the building by means of a rope drive, connecting the pulleys of the improvised motor and the alternator which it was desired to run.

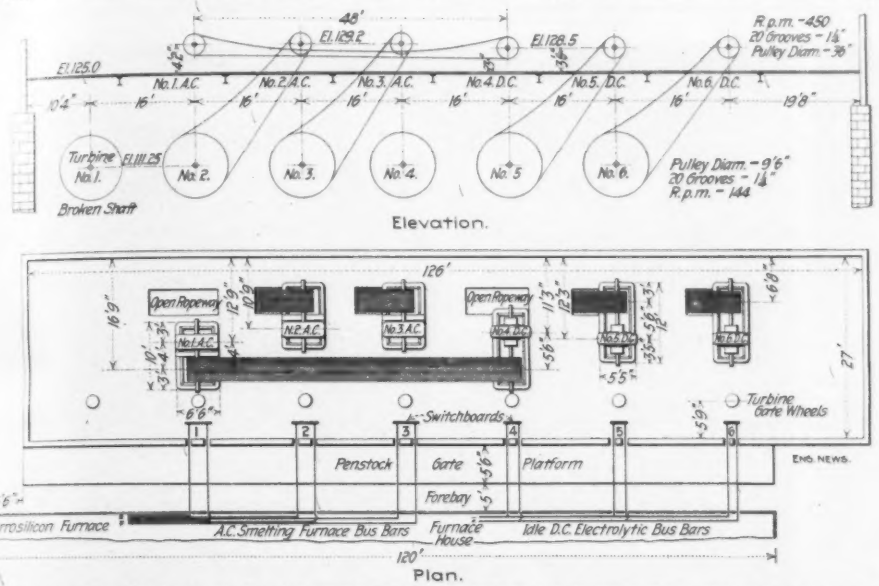



FIG. 1. PLAN AND SECTION SHOWING REARRANGEMENT OF MACHINES FOR TEMPORARY ROPE DRIVE; HOLCOMB'S ROCK POWER PLANT OF THE VIRGINIA ELECTROLYTIC CO.

The original inclined drives were of the English type of rope transmission, consisting of 20 separate bands of spliced rope. As these cost about $135 apiece, installed, they were not cut, but were laid off the turbine sheave and drawn upon the generator floor, where they appear in the photographs. It was impossible, owing to the looping of the drives with the generator bedplates, to separate them completely from their respective generators. Apart from appearance, this was no objection. The two machines were then turned bodily through 180°, placing both generator sheaves toward the forebay, and in line with the walkway of the house and with each other. The machines weigh twelve tons each, and the change was accomplished by two independent gangs of four men each, in one day. After alinement, an English rope-drive of 20 bands was spliced from pulley to pulley as tightly as practicable; then the motor-generator set was ready.

As the generators had been pivoted on their centers, there was little trouble in re-connecting their massive copper leads to the terminal boards once more; in the case of the alternator the terminal boards were both at one end of the frame, placing them out of reach of the copper cables. We had to bridge the gaps with gangs of copper ribbon, 8 ft. long, taken from an electrolytic furnace. A sheet of gasket rubber and a few pieces of plank served to insulate these temporary conductors from the generator frame. At the direct-current end such mechanical difficulties in re-connecting were not met, owing to the symmetrical arrangement of terminal boards and cables. Machine No. 4, when re-connected as a motor, was still parallel with generators Nos. 5 and 6, through the medium of the direct-current bus-bars in the furnace house. With incidental changes in instrument and field connections on the motor, the apparatus was ready for service.

The problem then encountered was of getting the alternator into synchronism with the other two. None of the turbines in the plant are automatically governed and synchronizing switchboards had been abandoned. It had been the practice to start all three turbines, driving the alternators, as nearly simultaneously as possible; the machines falling into step easily at a voltage slightly above zero.

There were no starting rheostats available of a capacity anywhere near what was demanded for starting up the direct-current motor of our improvised motor-generator set, and there was no time to rig up a salt water tank. Therefore we had to start up the motor, and the alternator driven by it, by starting the turbine of unit No. 5, which was to supply the direct-current. We planned to throw the alternator onto the bus-bars with the other two alternators, after we got up speed, and we rigged a temporary synchronizing board. But we did not have to use it as we were able to start the turbines of units 2, 3 and 5 simultaneously, and to bring the three alternators up to speed in synchronism, much as in normal operation.

We saw that our large shunt motor would not develop large enough torque on starting if self-excited. There would have been an initial rise of voltage and a rush of current to the motor. Even if the circuit breakers had held, this heavy current would have wiped out the little field magnetism of the generator (machine No. 5), and with it the terminal voltage. A second rise of voltage and rush of current would have followed which surely would have caused the circuit breakers to open as the turbine speed would be increasing. Therefore the field coils of both direct-current machines were separately excited from the exciter of the alternating-current units. This we knew would give us positive fields which would result in more certain generator voltage and stronger starting torque at the motor. We found that we could start the motor-generator combination and bring all the alternators up to speed in synchronism by starting up the turbines. The direct-current motor started uniformly at 18

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volts and 1,700 amps., the current quickly dropping back to 700 amps. immediately after the first impulse was given.

One further trouble had yet to be eliminated. The motor, under load, did not absorb the entire hydraulic power available for its generator until a potential of 140 volts was attained. This condition implied a 35% over-speed of the generator and of its turbine, with the latter working at a very poor efficiency. To counteract this trouble the motor field rheostat was used to reduce the excitation voltage at the machine to 66 volts in place of 125 which is standard of excitation and lighting in the plant. The usual effect of weakening the field excitation of a shunt motor is to accelerate the speed, but in this case the speed of the motor was not a function of its own operating voltage or current. The speed was really determined in the main by that of the turbine-driven alternators Nos. 2 and 3, with which alternator No. 1 was in synchronism. Barring an inappreciable slip in the rope transmission, the motor must of necessity rotate at the speed of its companion alternator, as the two were fitted with duplicate pulleys. The effect of weakening the field was the reverse of an acceleration. The speed of the motor fell off slightly, reducing that of the paralleled alternators. The motor absorbed more current; the speed of the generator driving it fell to a figure a little above normal, and the conditions for proper turbine efficiency were secured.

This action may be easily explained. The motor, in spite of reduced excitation, was unable to increase its speed, and thus to generate the former value of counter e. m. f. It therefore permitted the flow of additional current. This current, causing added load on the generator, effected a reduction in the speed and voltage of that machine, as there was no governor and no reserve power connected with that generator to maintain constant voltage.

The unusually large reduction in the voltage of field excitation of the motor could not be expected to be devoid of undesirable effect on the motor. Upon small motors this practice is seldom carried to the extent recorded for considerations of variable speed operation. The field in the air-gap of the motor was strongly skewed by armature reaction, and commutator sparking began. The motor brushes were moved to a lagging position 1.625 ins. from the neutral plane, when sparkless, cool commutation was secured, continuing through four months of service. Whatever doubt may have been felt of the reality of the extra absorption of current thus secured was dispelled by the wattmeter results of the day, as taken from the alternator switchboard. The operation of the two commutators of the motor at equal current, required an adjustment of the respective brush-rockers, equality being determined by the temperature. This method was as close as needed.

A few observations upon the efficiency of this emergency arrangement may be of interest. The power of the direct-current generator driving it was recorded as 180 KW., 1,500 amps. and 120 volts. Under the head of 18.7 ft., the best attainable here, a record performance of the generator has been noted of 194 KW. at 100 volts and 1,940 amps. The high voltage and speed conditions which could not be bettered, reduced the efficiency of this turbine by 7.2%. However, 180 KW. represents the best that could have been expected of the turbine No. 1, under normal arrangement of the plant, due to the fact that the alternators operate upon inductive load, and their turbines are always over-speeded to this extent. This loss, then, is not properly chargeable to the peculiar arrangement.

As the motor was controlled by its own switchboard, with only ammeter connections reversed, readings were taken at that point in the circuit, checking the generator output precisely. Thus the loss in electrical transmission may be regarded as zero. Respecting the losses of the motor, rope-drive and alternator, combined as a motor-generator set, the alternating current wattmeter on the switchboard of the alternator No. 1 gave at the same time 144 KW., or 80% of the energy input of the motor. This loss could not be divided into its elements without tedious determination of the characteristics of the two units concerned, but may be assumed fairly as follows: In motor loss, 5%; rope-drive loss, 10%; alternating-current generator loss, 5%. It will be noted that excitation loss does not enter into these figures, as separate excitation was used throughout. Considering that the motor was designed as a generator, and that the rope transmission was fixed by force of circumstances, the result was passable.

The arrangement was operated only to provide a necessary excess over the capacity of the two turbine-driven alternators, on account of this loss of 20%, which implied poor water economy. When, however, occasional storms furnished an abundance of water for a few days, the direct current generator, No. 6, was paralleled with No. 5, the former at part turbine gate, and the full power sent to the furnace. A typical reading at such times was as follows: Input of direct-current motor, 312 KW., 2,500 amps. (full load), at 125 volts; output of alternating-current generator, by wattmeter, 242 KW.; efficiency of set was 77.6%.

It is apparent that the losses at full load were slightly increased. The power output could have been forced further, but it was felt that the motor, at 2,500 amperes, was taxed enough. The rope-drive carried this record load without the stress usually evinced by slipping and consequent heating.

Were such an arrangement offered as an example of good practice, either in electrical or mechanical engineering, much criticism would be expected. An English rope-drive spanning 40 ft. between centers is not unknown, but between rope-sheaves of only 36 in. pitch diameter and with the tight run of rope only 23 ins. above the floor, so long a drive is unusual. It does not indicate the lengths to which good practice may be carried, but merely the possibility of operating such a drive in emergencies. It was not deemed wise to move the machines farther apart for the sake of the appearance of the drive, as the friction upon the babbitted bearings would have been rendered unnecessarily large. While the slack run of one or two ropes did, for a time, race along the floor at a usual velocity of 5,000 ft. per minute, the only effect was to polish a groove therein, without injury to the rope, which was internally lubricated with graphite. As a usual occurrence, the tight run of rope was practically straight, especially on the high load recorded. The slack run of the rope was operated very slack, and it was no unusual circumstance to see seven ropes of that run dipping below their own tight run, interlaced, in a sense, and running smoothly. Prediction that chafing would ensue was not supported by the result of 15 weeks' operation.

The manila transmission rope was from our stock, furnished by the American Manufacturing Co., of New York. The performance of the reversed generator calls for no special comment in view of the generally recognized satisfactory design of such machinery to-day.

As a matter of choice, an American-type rope drive of 20 wraps would have been chosen for a long drive upon small rope sheaves. The lack of a tension carriage and the time required to install one, prohibited the use of this improvement. It is worthy of statement that the set was kept in operation 18 days after the necessity had passed, as there was no need of the direct-current plant for that time, and as water was moderately abundant, power was generated in excess of the usual output of three alternators, turbine-driven; 824 hp. was secured where 770 had been developed before. It will be gathered from this that the makeshift ran well. Had it been a source of anxiety it would have been demolished as soon as possible. To meet the supposition that the service upon a horizontal drive of considerable length would tend to stretch and weaken the fiber of manila, it may be said that the ropes showed no reduction of area other

Fig. 2. Alternating-Current Generator.

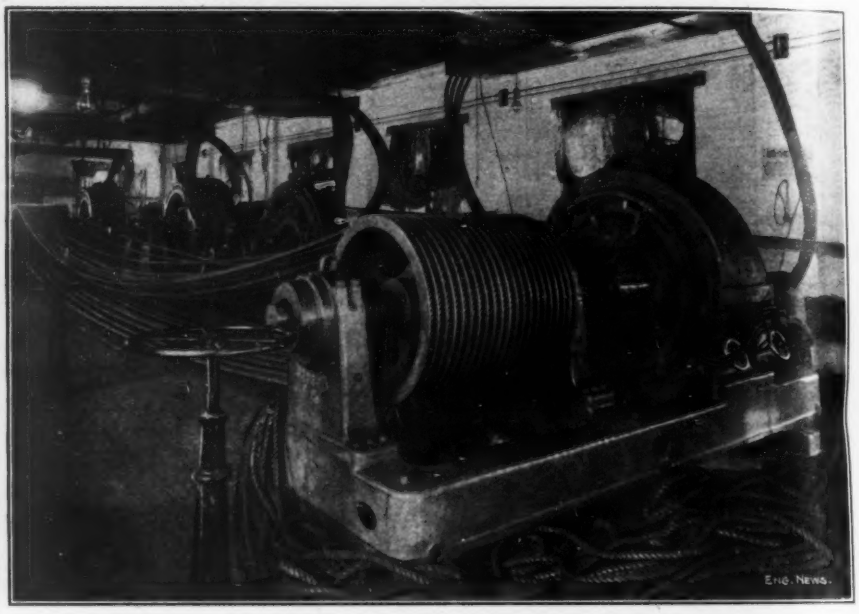


Fig. 3. Direct-Current Motor.

FIGS. 2 AND 3. AN EMERGENCY MOTOR-GENERATOR SET WITH A 40-FT. ENGLISH-TYPE ROPE DRIVE.

than usual on our inclined drives and in use. The photographs of Figs. 2 and 3 were taken on Jan. 4, after a service of 15 weeks. The machinery was photographed standing still and so does not present the favorable appearance given in running. But it shows the practicability of splicing an English-type rope drive with fairly even tension. The drive was laid by Mr. George L. Price, the chief attendant of the plant. The credit of turning the two heavy generators completely around in ten hours, with only such tools as screw-jacks, chain block, and greased steel plates, is due to the master mechanic of the works, Mr. James T. Hall.

The importance of the adoption of this emergency measure was evident during the week while the change over was in progress. The production of ferro-silicon was below two-thirds of the normal, with the power of two alternators. This is readily explained by the fact that such a furnace has fixed losses, regardless of the power input. Some trouble was experienced also in producing an alloy of a grade considered marketable. Even though operating intermittently, according to the water available, the wattmeter records of the alternator thus driven, up to the date when the turbine No. 1 was again ready for service, credit this makeshift set with the production of alloy worth $3,600, which would have been lost, had nothing been done.

## The Measurement of Two Primary Base Lines with Invar Tapes.*

By WILLIAM BOWIE.†

There are several types of base apparatus which have been used successfully in recent years by the Coast and Geodetic Survey in the measurement of primary base lines. They are: (1) The secondary apparatus, a monometallic multiple-bar system; (2) the duplex apparatus, a bimetallic multiple-bar system; (3) steel tapes, 50 and 100 meters in length; and (4) nickel-steel or invar tapes of 50-meter lengths.

The iced-bar is a measuring apparatus of great precision but it has only been used in the determination of the length of comparators upon which other apparatus have been standardized.

The secondary bars and the duplex bars gave very accurate results and while less expensive in their operation than the Repsold and other apparatus in use in Europe, yet their operation was more expensive than tapes. For this reason there was a tendency to limit the number of bases in a scheme of triangulation, beyond what is desirable, and the lengths of the bases were made comparatively short.

Tests made at the Holton base in 1891 by Prof. R. S. Woodward indicated that primary base lines could be successfully measured with steel tapes. Steel tapes of 50 and 100 meters in length were used in connection with the duplex bars in 1900 in the measurement of nine bases along the 98th meridian. The party was in charge of Mr. A. L. Baldwin, who completed the measurement of these nine bases, 69 kilometers total length, in six months.‡ Only one-fifth of the total measurements was made with the bars.

In 1906 six primary bases were measured with both steel and invar tapes 50 meters in length, by a party under Assistant O. B. French. These bases, with a total length of 60.5 kilometers, were completed in four months.

It will be seen that the measurement of a base with tapes occupied about 20 days. This included traveling between bases. The measurement of a primary base with bars usually took several months.

As the nickel-steel or invar base tapes were satisfactory in the measurement of six primary bases in 1906, it was decided to use them in measuring the two base lines, one at Stanton, Texas, and one at Deming, New Mexico, on the Texas-California arc of primary triangulation. The invar tapes held their lengths well during the season of 1906, and because of their small coefficients of expansion it was possible to do the measuring in the hours of daylight. The average coefficient of expansion of the invar tapes used on the primary bases by this survey is only about 0.04 that of steel, hence an error of 2.5° in the temperatures of an invar tape would make only the error caused by an erroneous reading of 0.1° in the temperature of the steel tape.

As it was found, during the work of 1906, to be unnecessary to standardize the tapes in the field, it was decided to have the base lines on the Texas-California arc measured by the triangulation party when the triangulation had progressed to the vicinity of the bases.

There are only two base lines on this arc. This triangulation extends about 1,200 miles from the 98th meridian triangulation in the vicinity of Weatherford, Texas, to the Pacific coast primary triangulation near San Diego, Cal. The locations of the base lines were made to depend upon the summation of the strength of the individual figures rather than upon the number of figures or the length of the scheme between bases. The average distance between bases on the 98th meridian is about 120 miles, while the distance between the nearest base on the 98th meridian and the Stanton base is 254 miles, from the Stanton base to the Deming base is 390 miles, and from the Deming base to the Los Angeles base is 628 miles. The average of these three distances is 427 miles.

Very little increase in accuracy of the lengths of the triangle sides in the triangulation connected with a base results from increasing the accuracy of the base measurement beyond that represented by a probable error of one part in 500,000 in the length of the base. The chief of party was expected to keep the accuracy of his work as far within this limit as was possible by the use of good judgment and skill, but he was expected to restrict the time and money expended upon each operation substantially to that required to keep barely within the limit of one part in 500,000.

Four invar tapes, each 50 meters in length, were carried to the field, and three of them were used in the measurements. One was held in reserve for use in case of accident to one of the other three. These four tapes were standardized at the Bureau of Standards before and after the measurement of each base. The bases were measured in sections of approximately one kilometer in length. One-third of the total measurements on a base was made with each of the three tapes and each section was measured with two tapes. This method gave an inter-comparison of the several tapes used.

Such precautions were taken to secure accurate horizontal and vertical alinement of the tapes and the determination of the tension applied as was necessary to insure that the errors rising from these sources were less than one part in a million.

The Stanton base was on the prairie with no serious obstructions, and it was only necessary to remove some small brush in preparing the line for stake setting and measurement. Its length is 13,193 meters. The size of the party on the Stanton base was two observers and seven other men. One of the observers was Mr. J. S. Hill, the chief of party. During actual measurements only six persons were engaged.

There has been a great change in recent years in the stretcher used to apply tension to the tape. The one used in 1900 weighed about 47 lbs. and consisted of a lever hinged by a universal joint to a platform on which the operator stood. This lever was made of a piece of steel tubing, terminating in a hickory handle. Along the upper two-thirds of the tube was cut a screw thread on which a wheel nut played freely. This nut gave a vertical motion to a gimbal-jointed support to which a spring balance was attached.

This stretcher was first used on the Holton base. In 1906 it was changed by removing the platform and substituting a metal shoe which at each setup was pressed into the ground to hold the stretcher in position. In this modified form it weighed something over 30 lbs.

The stretcher used in the measurement of the Stanton and Deming bases in 1909 and 1910 was designed by Signalman Jasper S. Bilby and made in the field, under his direction. It weighed only 18 lbs. A stretcher recently made in the Instrument Division of the Coast and Geodetic Survey for future use on primary base measurements embodies the general principles of the stretcher used on the last two bases measured. It weighs only 11½ lbs. This stretcher has a sliding collar which can be brought quickly to any desired position by means of a friction lever device. This collar supports the balance and takes the place of the wheel nut of the old stretcher.

The adoption of this simple and light stretcher is a step in the right direction, for the amount of measuring accomplished by a party in any one day depends largely upon the endurance of the man carrying the forward stretcher. Nearly all the measurements by other nations with tapes or wires are made with weights and pulleys to stretch the apparatus. Even the simplest form used by them requires a larger party and very much more time in operation than our stretcher, and no greater accuracy is attained.

As in previous base measurements, the rear end of the tape was held by a simple wooden staff fitted with a metal shoe, the end of the tape being fastened to the staff by a strap.

On the Stanton base three supports were used for the tapes; one at each end and one at the center. The tape lengths were marked on copper strips which were fastened to the top of the end supports. During the measurement of this base and especially during the day, there was usually wind of considerable force. The invar tape has a tendency not to lie perfectly flat or smooth; that is, the elements of the tape normal to its length are not horizontal when it is suspended with tension applied and ready for measurement. With this peculiarity, it is more sensitive to the wind effects than the steel tape. A number of sections of the Stanton base which were measured in a strong wind had to be remeasured under more favorable conditions in order to secure the required degree of accuracy.

A base 15,554 meters in length was measured in the vicinity of Deming, N. Mex., in 1910, by the party which had measured the Stanton base in the previous year. The work was done in the same manner as on the Stanton base, except that five supports were used for each tape length. With this number of supports the tape assumed a position more nearly horizontal and the effect of the wind on the results was practically negligible.

The probable error of the measurement of the Stanton base was 5.15 millimeters or one part in 2,560,000, and for the Deming base 7.93 millimeters or one part in 1,960,000. These probable errors are about the same size as those of the work done in 1900 and 1906.*

The measurement of the Stanton base occupied the party 17 days and the total cost of the field and office work connected with it was $868. To this cost was added $400 which represents the approximate expense to the Bureau of Standards in making two standardizations of the four tapes. This should be done in order to make a comparison with previous work when the tapes were standardized in the field. This makes a total cost of $96 per kilometer measured.

The Deming base was completed in about 13 days and the total cost of the field and office work was about $700. To this should also be added $400, representing the expense to the Bureau of Standards in the standardization of the tapes. This makes a total cost of $72 per kilometer.

The cost of the measurements by steel tapes alone in 1900 was about $98 per kilometer, and in 1906 the cost of measurements by the invar tapes alone was approximately $94 per kilometer.

The actual measurements with the tapes on the Deming base were completed in three working days. This means that an average of over ten kilometers, involving 200 tape lengths, were completed each day.

Some geodesists of foreign countries have reported that invar tapes would not hold their lengths during field measurements. This has not been the experience of the Coast and Geodetic Survey during the measurement of the six primary bases in 1906 and of the two bases in 1909 and 1910. The results of the field measurements were most satisfactory and the three standardizations of the three tapes used in the actual measurements and the reserve tape show differences which were not as great, in any case, as one part in 400,000. In most cases the difference between two standardizations of a tape was not more than about one part in a million, which is comparable with the actual errors of the standardizations.

Some of the conclusions which may be drawn from the measurements of the Stanton and Deming base lines are:

The cost of measuring a single base line, or several base lines widely separated, by the triangulation party when in the vicinity of each base line, will be much less than when they are measured by a party organized especially for the purpose. Where there are a number of base lines to be measured, which are not widely separated, as was the case on the 98th meridian, the cost would not be very different whether they were measured by the triangulation party or by a party organized for base-line measurements only. When a base is measured by a triangulation party, what may be called the unproductive periods, before and after the measurement, are eliminated. Such periods are usually occupied by traveling to and from the base and in organizing and disbanding the base party.

The 50-meter tape has been found to be both convenient and satisfactory, thus confirming the conclusions based upon previous tape work in this Survey.

Invar tapes, with measurements made in daylight or at night, give results which have probable errors comparable with those obtained by the duplex base bars, which were used to measure the Salt Lake base, and in 1900 in connection with steel tapes, in the measurement of nine bases along the 98th meridian.

It is not necessary to standardize invar tapes in the field.

Owing to their smaller coefficients of expansion, invar tapes give more accurate results than steel tapes.

With proper care during measurements in the field, the invar tape does not change appreciably in length. While not so elastic as steel, yet it is sufficiently strong to withstand the ordinary shocks due to excessive tension, and no change in its length should be caused by using a reel which has a diameter of 16 ins. or more. The tape should not be dragged along the ground but should be carried forward by the members of the measuring party.

To minimize the effect of winds, the 50-meter invar tape should be supported by five stakes, equally spaced, two of these being the end supports on which the markings of the tape lengths are made and the other three being the intermediate supports from which the tape is suspended. By using this number of supports, measurements may be made with an invar tape during wind which would make it impracticable to secure good results were the tape on only three supports, one at each end and one in the center. It is believed that more than five supports should not be used for a 50-meter tape, for with a decrease in the distance between supports the difficulty of obtaining the grade corrections is increased.

*A paper read before the Philosophical Society of Washington, D. C., Jan. 28, 1911.

†Inspector of Geodetic Work, U. S. Coast and Geodetic Survey.

‡See Engineering News, Sept. 4, 1902, pp. 162, 168.

*See Engineering News, Dec. 5, 1907, p. 612.

# Proposed Water Storage on the Genesee River for Flood Prevention and Amelioration of Low-Water Conditions.

By A. H. PERKINS,* Assoc. M. Am. Soc. C. E.

On Dec. 15, 1910, the New York State Water Supply Commission, acting upon a petition of the Supervisors of Monroe Co., filed simultaneously in the counties of Monroe, Livingstone, Wyoming and Allegheny maps, plans and specifications of the proposed Portage Reservoir, and lists of the various properties to be benefited thereby.

While water storage for the prevention of floods and the improvement of the water powers of the State of New York was the subject of an official investigation as far back as 1875, when Prof. F. N. Benedict made a report to the legislature designed to show to what extent the waters of the Adirondacks might be controlled for the benefit of navigation, water power and public water-supplies, it was not until after the extended damages caused by the floods of 1902 that any very active steps were taken. As a result of the state-wide floods of 1902, the Water Storage Commission was appointed and made an extended report. The River Improvement Commission was created in 1904 to continue the work under the River Improvement Act of that year. The New York State Water Supply Commission was created in 1905 for the purpose of passing upon new municipal water-supplies in the state and of securing an equitable distribution thereof. In 1906 the powers of the River Improvement Commission were transferred to the Water Supply Commission.

The River Improvement Act of 1904 and its subsequent amendments provided that any riparian owner, or the proper officers of any county, town, city or village located upon a stream may petition the commission for the improvement of that stream for the benefit of the public health and safety, and that the commission must thereupon determine whether or not the stream is of sufficient importance to warrant action by the state. If the commission determines in the affirmative, it must cause to be made studies, surveys, etc., to determine the feasibility of improving the stream. If it decides that it is practicable to control the stream by the construction of works upon it, or by other means, the commission causes preliminary maps, plans, estimates, etc., to be made and filed, together with a tentative apportionment of the estimated cost between the individual owners of property to be benefited taken collectively, and the various political divisions of the state which are to be benefited. After advertising and holding public hearings, the commission may make changes and call further hearings or may "enter a final order" for the construction of the work and prepare final plans, estimates and specifications, but before proceeding beyond this point the "final order" must be approved by the legislature.

After approval by the legislature, a "river improvement district" is formed and the bonds of the district sold, contracts for the construction of the work are then let by the commission. For the payment of the bonds the commission is to assess the costs upon the property of the improvement district in proportion to the benefits conferred upon each parcel, and the civil divisions of the state are to collect the amounts as they become due from the owners of such parcels in the same manner and at the same time as other taxes are collected. There is also collected at the same time the various amounts assigned to each civil division as a whole. In this transaction, the state acts simply as the agent of the improvement district, and neither collects nor receives anything beyond the actual costs of the improvement.

In 1907, in response to a strong message on the subject of water powers from Governor Hughes, the legislature passed the "Fuller Bill." The title of this law is,

**An Act authorizing and directing the State Water Supply Commission to devise plans for the progressive development of the water powers of the state for the public use, under state ownership and control and making an appropriation therefor.**

In addition to the provisions indicated in the title, the commission was directed to present a draft of a bill to carry into effect its recommendations. The report of the commission, made early in 1910, contained a resumé of operations under the Fuller act and the draft of a bill as required. The state having been the client of the commission, the bill was considered by water-power interests to be too favorable to the state and the bill failed to pass the legislature of 1910. It was intended by this bill to provide not only for the repayment to the state of all costs of storage reservoirs, but where the benefits conferred exceed the portion of costs assessed, a revenue was to be derived by the state. It was this latter feature to which the water-power owners objected. It was hoped by all parties concerned that some appropriate legislation would be passed last winter because of the believed inadequacy of the river improvement act to meet all the conditions involved in water storage for power purposes as well as for flood protection. As the river improvement act is the only existing law under which action can be had, it has been determined to proceed as far as possible under that law.

In 1907 the Supervisors of Monroe Co. filed a petition under the river improvement act and in 1908 secured an appropriation of $25,000 for continuation of the studies on the Genesee by the commission, under the river improvement act. The commission was also expending some sums on this watershed under the Fuller act. As a result the commission has determined that the Genesee River is of sufficient importance to warrant action by the state and that the river can be controlled by a dam at Portage; has caused preliminary maps, plans, specifications and estimates to be filed, as stated at the beginning of this article, and has advertised that a hearing will be held in Rochester, Feb. 2, 1911.

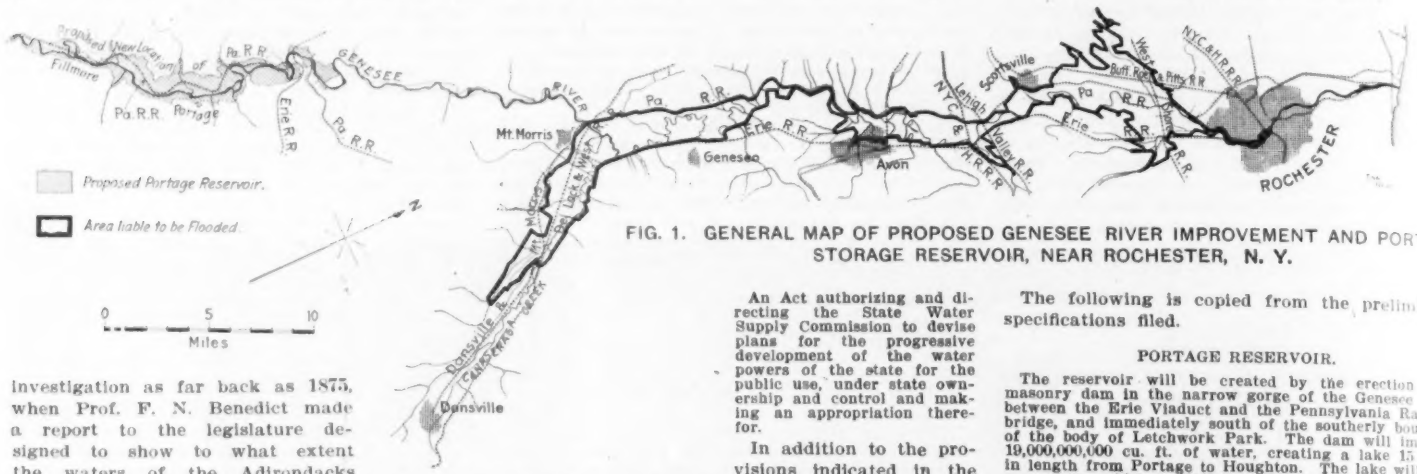


FIG. 1. GENERAL MAP OF PROPOSED GENESEE RIVER IMPROVEMENT AND PORTAGE STORAGE RESERVOIR, NEAR ROCHESTER, N. Y.

The following is copied from the preliminary specifications filed.

### PORTAGE RESERVOIR.

The reservoir will be created by the erection of a masonry dam in the narrow gorge of the Genesee River between the Erie Viaduct and the Pennsylvania Railroad bridge, and immediately south of the southerly boundary of the body of Letchwork Park. The dam will impound 19,000,000,000 cu. ft. of water, creating a lake 15 miles in length from Portage to Houghton. The lake will have an average width of 1¼ miles and a surface area of 13½ square miles; the extreme depth of the water at the dam will be 135 ft.

The plans for the dam and reservoir contemplate a normal flow line at Elev. 1198, to which level water will ordinarily be stored. The portion of the basin between Elevs. 1198 and 1215 will be reserved for the storage and control of flood waters. This portion of the basin has a capacity of 6,000,000,000 cu. ft., and is sufficient to control a flood equal to the largest of which there is any record.

All the land in the reservoir basin below the taking line, Elev. 1220, is to be purchased and owned by the State of New York and from it all buildings and related structures and standing forests are to be removed. The bodies and monuments in the two cemeteries in the basin are to be removed to a new site at the expense of the State. In the preparation of the reservoir basin to receive the water, great care will be taken to remove everything which might become unsightly or a menace to health when the water in the reservoir is drawn off. All woods and standing trees will be removed and the stumps cut close to the ground or removed by blasting or otherwise; all brush, grass, and other vegetable matter will be cut and burned. Especial attention will be given to the preparation of the sidehill slopes at the elevation of the flow line and for some distance below, so that the appearance of a natural beach may be obtained as nearly as practicable. The buildings in portions of the villages or hamlets of Portageville, Rossburg, Wiscoy, Fillmore and Houghton are below the flow line elevation and will be removed or destroyed.

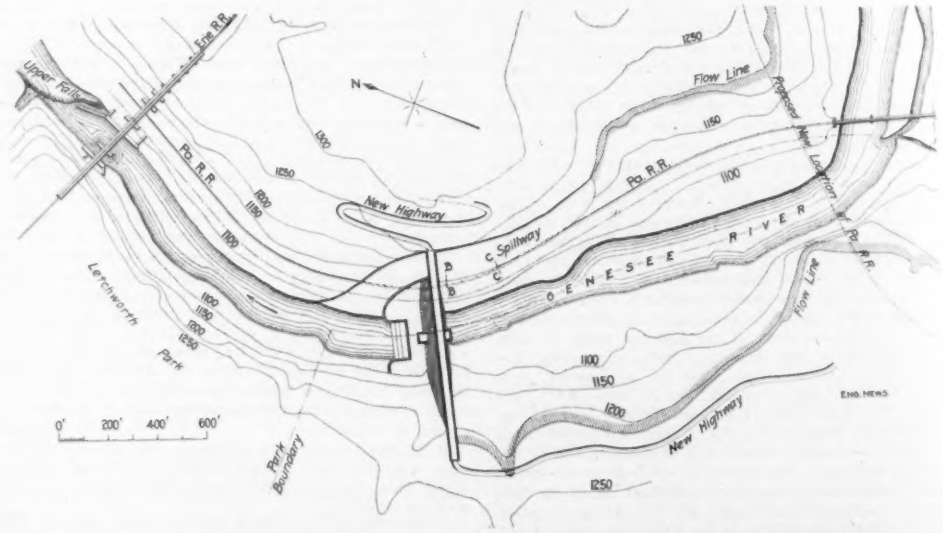


FIG. 2. GENERAL PLAN OF PROPOSED PORTAGE DAM AND RESERVOIR, NEAR ROCHESTER, N. Y.

### PORTAGE DAM.

MAIN DAM.—The Portage Dam is to be located about 1,600 ft. up stream from the upper Portage Falls. It is to be a masonry structure, founded on rock, and will be composed in the interior of large blocks of stone em-

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bedded in Portland cement concrete. Both faces of the dam to the depth of 2 ft. are to be of high-grade concrete, and the up-stream facing concrete is to be waterproofed. The surface of the lower face is to be tool-dressed or bush-hammered. A roadway with ornamental railing on either side will be provided across the top. Considerable care and expense will be incurred in the design and construction of the dam to secure architectural effects in harmony with the natural surroundings. In plan, the dam will be straight, and in cross-section will be somewhat heavier than sections of the new Croton and other large dams constructed according to modern scientific plans.

DISCHARGE PIPES.—Through the central part of the dam there will be four cast-iron pipes of sufficient size to carry 1,500 sec.-ft. of water. These pipes are to be controlled by suitable gates and valves, and will be used in letting water out of the reservoir for the various purposes of flood control, maintaining a uniform flow in dry weather, and water for scenic effects at the falls in Letchworth Park. In order to reduce the velocity of the water at the point of discharge, the pipes, after passing through the dam, end in a masonry enlargement or culvert and in order to further reduce the velocity of the issuing water and prevent erosion near the toe of the dam, the discharge is into a pool formed by an auxiliary dam 15 ft. high, placed 25 ft. down stream from the outlets of the culverts.

SPILLWAY.—The spillway, 800 ft. long, will be built at right angles to the main dam, beginning near its eastern end. The spillway channel will be formed by excavating the rock in the side hill and will carry off the water flowing over the spillway and conduct it under a concrete arch of 100 ft. span at the east end of the dam. The spillway concrete dam is to be 30 ft. high at its maximum section near the main dam, and vary from that to a minimum height of 4 or 5 ft. at its southern end. Its top is to be at Elev. 1212. Its discharge capacity with a crest depth of water of 5 ft. is 30,000 sec.-ft. In addition to the overfall, water will be discharged through orifices left in the spillway dam at Elev. 1198, the object of which is to provide, while the reservoir is filling above flow line 1198, an outlet for only so much water as the stream channel below will carry without overflowing, thus preventing floods on the low lands and in Rochester. The openings also insure the prompt and automatic drawing off of the water stored for flood prevention preparatory to another filling in case a second heavy rainfall succeeds. The water falling over the spillway dam is conducted by a training wall to the stream bed 300 ft. below the toe of the dam.

Following are the principal dimensions of the dam and spillway:

| | |
|---|---|
| Length of dam on top | 800 ft. |
| Height, foundation to coping | 152 " |
| Thickness at bottom | 115 " |
| Thickness at river bed | 105 " |
| Thickness on top | 30 " |
| Length of spillway dam | 800 " |
| Volume of masonry, including spillway | 184,000 cu. yds. |

The dam will impound the following volumes of water at the given elevations:

| | Billions cu. ft. |
|---|---|
| Elev. 1080, lowest point of reservoir | 0.00 |
| " 1120, lowest point to which storage is to be drawn | 0.39 |
| " 1198, begins to spill (through openings) | 13.77 |
| " 1212, top of regular spillway | 18.77 |
| " 1215, maximum flood height | 19.94 |
| " 1120 to 1198, normal storage | 13.38 |
| " 1198 to 1215, flood storage | 6.17 |

The Rochester division of the Pennsylvania Railroad runs in the valley throughout the length of the reservoir and will have to be relocated on higher ground. The relocation and reconstruction of 25 miles of highways is provided for in the estimates.

The cost of the complete works, including the portions of the railway and highways involved, is estimated at $4,588,215, divided as shown in the following table:

| | |
|---|---|
| For the dam and appurtenances | $1,717,215 |
| For the reservoir, exclusive of the dam | 2,817,000 |
| For removing obstructions in the river channel below, 50 miles | 20,000 |
| For refund to State Treasury for moneys advanced under Chap. 466, Laws of 1908 | 25,000 |
| For legal, engineering and incidental expenses to carry proceedings to and including the final maps, plans, estimates and statements | 25,000 |
| Total | $4,588,215 |

The Genesee River is a particularly "flashy" stream, owing to the practically complete denudation of its basin, the steep slopes of the area, and the entire absence of natural regulation from large lakes within its drainage area. In dry years, such as the three just passed, the low-water flow falls to 200 sec.-ft. at Rochester, while it is estimated that in the flood of 1865, the flow was 55,000 sec.-ft. at the same point.

There are about 30,000 acres of the best farming land of the state lying between Mt. Morris and Rochester which are subject to overflow at frequent intervals. The flood of 1902 was estimated to have caused over $1,000,000 damages in the city of Rochester alone, although it was by no means the greatest flood on record. Study of the subject seems to demonstrate that all flood damages along the Genesee River can be avoided by holding back 6,000,000,000 cu. ft. of water in the Portage Reservoir, and it is the intention to keep this portion of the reservoir capacity always ready to receive that amount of water. The remaining storage capacity created by the dam, amounting as previously noted to 13 billion cubic feet, will be used for storing water to ameliorate low-water conditions along the stream below. From the standpoint of public health, the principal result achieved by the use of this latter portion of the stored waters will consist in the dilution of the large amount of sewage now reaching the stream and the prevention of the results of stagnation. The principal benefits, and those for which the greater part of the cost of the work will be assessed, are benefits which will accrue to water powers as a result of the regulation of the stream.

Within the limits of the city of Rochester, the Genesee River has a total fall of 252 ft. Of this amount, 228 ft. is now developed in four stages, with a total rated wheel capacity of 29,220 HP. and 17,000 auxiliary. During an average year, these wheels can develop from the unregulated flow of the stream 22,600-HP. years. They would be operated by the natural flow of the stream 58% of the time at full capacity. If no more wheel capacity be installed, the regulated flow of the stream will develop 27,800-HP. years during the average year. After regulation and complete development of the total head of 242 ft. estimated as available at Rochester, 42,000-wheel HP. can be operated at full capacity 60% of the time on the average and there will be produced by the water 38,900-HP. years per year. The capacity of the auxiliary plant necessary to take care of part of the load during the remaining 40% of the time will be about 15,000 HP., and it will have to develop 3,122-HP. years per year on the average.

In view of the fact that there is a ready market at Rochester for all this power, it is seen that the construction of the Portage Reservoir, taken in connection with some changes in plant, will result in increasing the energy furnished by the Genesee River within the city limits of Rochester by 72%.

It is expected that there may be made available at Rochester a pondage sufficient to take care of the question of load factor completely.

Some well-intentioned but poorly-informed people have opposed the construction of the reservoir on the ground that it may injure the beauty of Letchworth Park. As a matter of fact, if the work were actually to be an eyesore, the only portion of the reservoir that will be visible from any accessible point in Letchworth Park will be a portion of the front of the dam, and it is believed that few fair-minded persons will contend that the structure proposed will detract from the natural scenery, especially as it must be seen through an intervening high-trestle crossing of the Erie Railroad. The only time when visitors go to Letchworth Park in any numbers is during the summer, and the flow of the water over the falls will be greater during that season because of the reservoir than it now is without it. An honest study of the facts relating to this phase of the enterprise and a visit to the site should convince any good-intentioned person that the great natural beauties of Letchworth Park will be enhanced by the construction of this reservoir. It is so seldom that commercial advantage and enhancement of natural scenic effects go hand in hand, that this instance should be a welcome variation from the usual.

All the engineering work is under the direction of Mr. Walter McCulloh, M. Am. Soc. C. E., Consulting Engineer to the commission.

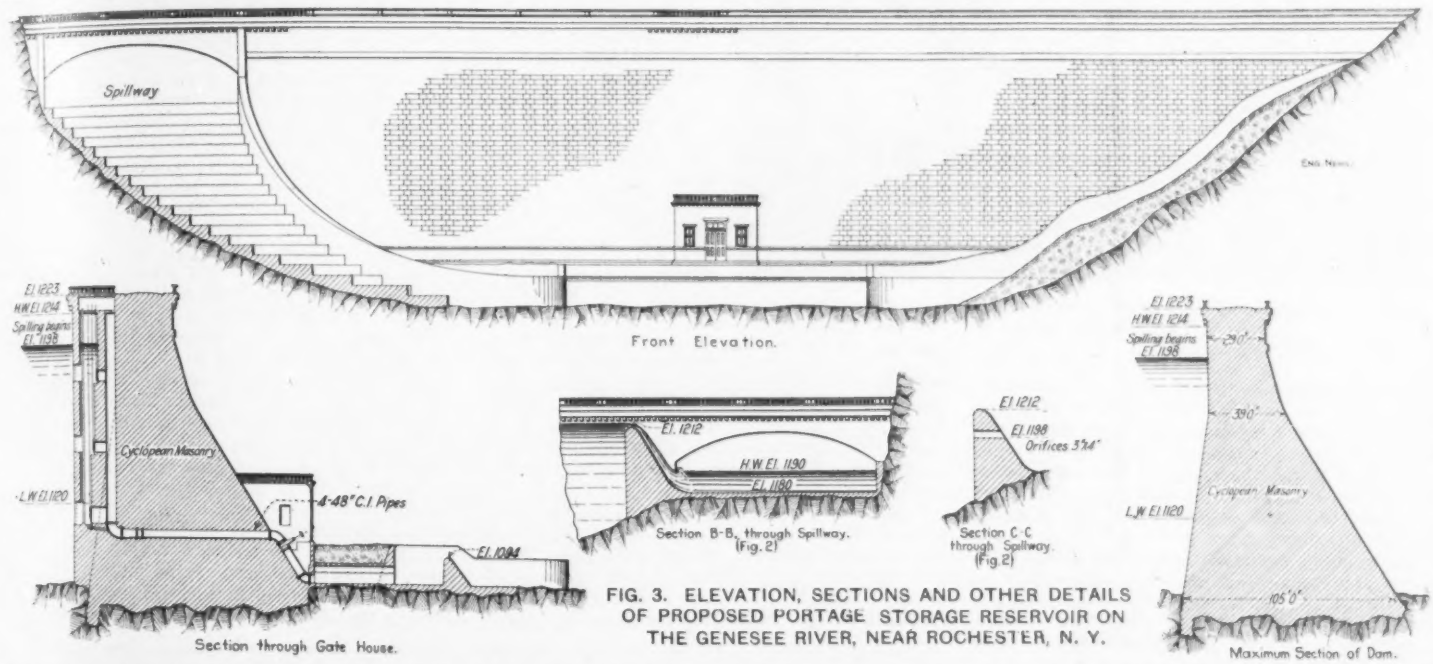


FIG. 3. ELEVATION, SECTIONS AND OTHER DETAILS OF PROPOSED PORTAGE STORAGE RESERVOIR ON THE GENESEE RIVER, NEAR ROCHESTER, N. Y.

HIGH-HEAD HIGH-EFFICIENCY IMPULSE WHEELS were built by Escher Wyss & Co., of Zurich, Switzerland, for a peak-load electric generating station for Milan at Isola, Italy. Each wheel (of four) is rated at 6,500 HP., and has a single deflecting needle-nozzle. The diameter of the wheel is 108¾ ins. on the pitch circle; the head is 2,800 to 3,000 ft., and the speed of the wheel is 420 r. p. m.

The maximum efficiency on test was 88%. At 2,200-HP. load an efficiency of 80% is reached, and the curve thence upward is very flat, with a value of about 86% at 7,200-HP., i. e., 11% overload. The plant is described in "Schweizerische Bauzeitung" of Jan. 7 and Jan. 21, 1911, the turbines in the latter issue.

## Some New Excavating Machines.

A number of types of excavating machines employed for ditch and trench excavation were described in our issue of Feb. 23, 1911, p. 215, and we supplement that article by the following further particulars of three new machines which have been designed for work of this kind. These include (1) a machine for ditch, trench and general excavation work; (2) a machine intended specially for trenching in firm ground; (3) a machine for excavating ditches in soft and wet ground.

### The Jacobs Excavator.

This machine, shown in Fig. 1, is of the drag-line or scraper bucket type, but the bucket travels upon a curved boom instead of being handled entirely by cables as in most machines of this type. The machine is a revolving derrick-car or traveling derrick with a straight steel boom guyed from an A-frame by a topping lift. Pivoted to the front sill of the car frame (at a point just below the heel of the boom) is a curved boom 40 ft. long, the outer end of which is vertical and is slung from the head of the hoisting boom. The bucket is attached to a trolley which travels on the curved boom, having two double-flanged wheels riding on the upper flange and a third wheel bearing against the lower flange to keep the bucket from "kicking" upward. The guide boom holds the bucket down to its work, so that it cannot ride over hard spots or boulders. In making the cut, the bucket is hauled inward by a cable leading directly from the trolley to the engine. For dumping, it is hauled outward by the back-haul cable which leads from the trolley to the head of the hoisting boom and back to the engine. The bucket is dumped by continuing its travel to the vertical end of the guide boom, the boom being first swung round to the position at which the load is to be deposited. The bucket has no sheaves, latches or other movable parts.

The depth of cut is regulated by raising or lowering the curved boom. For narrow excavations, such as trenches, the machine may make a longitudinal cut. For wider work, such as ditches or canals, the cut may be made transversely, giving any desired side slopes, while if the excavation is still wider the machine may work along the bottom of the cut. Backfilling can be done readily, the bucket scraping the material into the cut.

The framing of the derrick is of structural steel, and the upper or revolving frame has a turntable platform mounted on cast-steel rollers (with brass bushings) which run on a circular rail. This rail is carried by the steel underframe, which is mounted on double-flanged steel wheels. The machine travels on a track of railway rails; in moving, the rails are handled by the machine, which picks them up from the rear and swings them into position in advance. Its working radius is 45 ft. It is self propelling, using the bucket as an anchor and hauling on the bucket cable to pull the machine forward or backward as desired. There is a three-drum hoisting engine, with the two main drums mounted on the front end. Slewing and hoisting can be done simultaneously. The operator is stationed at the front end, where he has a good view of the work, and all operations are controlled by three levers and a foot brake.

This machine is used for digging new drainage ditches and cleaning out old ditches. For the latter work, it may travel along the side of the ditch (leveling its own roadbed) or it may be mounted on a platform spanning the ditch (up to a width of 30 ft.). It is used also for trenching for sewers and tile drains, and can then do the backfilling also. It may be used also for building roads, stripping quarries or coal beds, and for general excavation.

FIG. 1. A DRAG-LINE EXCAVATOR WITH AUXILIARY BOOM FOR THE SCRAPER BUCKET.
(Jacobs Engineering Co., Ottawa, Ill.; Builders.)

In a modified form for sewer and water pipe work, the booms are fitted to a bull-wheel and revolve independently of the machine, which remains stationary. With the guide boom removed (by simply taking out its heel pin and detaching its head from the cable), the machine can be used as a locomotive crane; also to handle skips or excavating buckets of the clam-shell and orange-peel types.

This excavator is the invention of C. C. Jacobs and F. Jacobs, of Amboy, Ill., and is manufactured by the Jacobs Engineering Co., of Ottawa, Ill. The machines are made in different sizes, with buckets of ¾-yd. to 2 yds. capacity, and booms 25 to 50 ft. long. They may be operated by either steam or gasoline engines. The working force comprises an engineman and trackman, with a fireman also when a steam engine is used.

This machine was used by John M. Egan, Jr., contractor, of Amboy, Ill., on the construction of the Raymond drainage district in Kendall County and the Rob Roy drainage district in Kane County (Illinois). This work included 5½ miles of tile ditch for 16 to 30-in. drain tile, ¼-mile of open ditch, and ¼-mile of cleaning an old open ditch. The open ditch was 10 ft. wide on the bottom, 6 ft. deep, with side slopes of 1 on 1. The tile ditch was from 5 to 14 ft. deep, with a top width of 3 to 10 ft., according to the depth and the character of the material. The material excavated was running sand, coarse red sand, gravel and clay of different kinds, and black loam. The rate of progress ranged from 200 ft. to 400 ft. per day, varying with the size of tile, the character of the material, and the amount of running water and ground water encountered. The fuel consumption was about ¾-ton per 10-hour day. The machine traveled along the center line of the ditch, making a longitudinal cut, and propelling itself upon its track of 80-lb. rails laid on wooden blocks. The force for operating the machine was composed of four men: engineman, fireman and two trackmen. For the tile laying the force was as follows: foreman, two tile layers, one laborer and one man with team to haul coal and water.

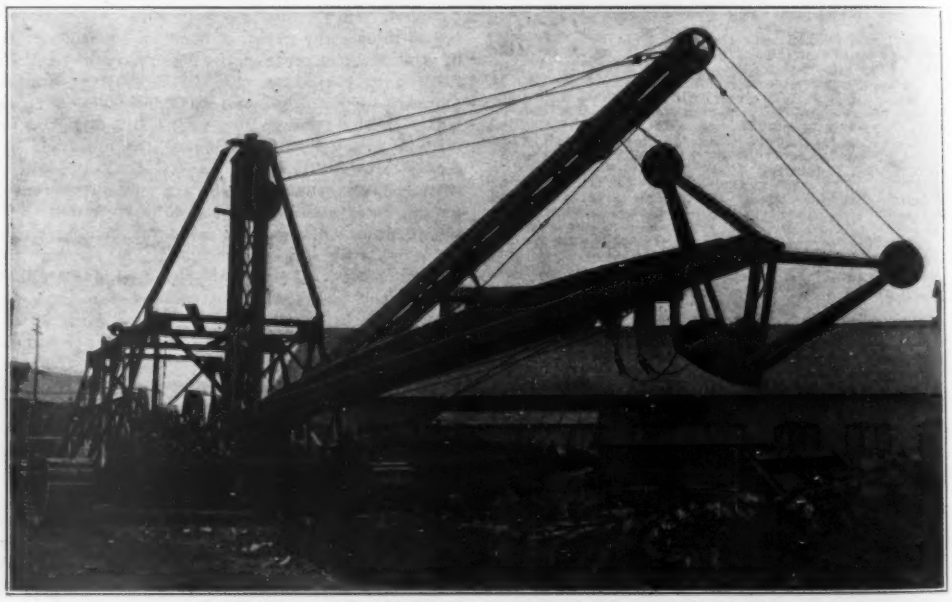

FIG. 2. A DRY-LAND DREDGE OR TRAVELING EXCAVATOR FOR DRAINAGE DITCHING.
(The Fairbanks Steam Shovel Co., Marion, O.; Builders.)

### The Monahan Trench Excavator.

This machine is of the endless-chain type, the chains being fitted with cutters or buckets and traveling on a ladder frame which is raised or lowered according to the depth required. This ladder frame is pivoted at the rear end of a tractor which carries the operating machinery. The shape of the buckets is one of the special features of the machine. They are steel bars 1 × 6 ins., attached to the chain links by arms in such a way that they swing away from the chain in making the turn at each end of the ladder. The bars are fitted with cutters, those of alternate bars being staggered so as to cover the full width of the face of cut. A breaking pin at each bucket is provided so that in case of severe strain (as in striking a boulder) this will part and release the bucket uninjured. A new pin can be placed readily. The chains pass over a five-sided driving sprocket wheel at the top of the ladder frame, but at the bottom a roller is used instead of a sprocket wheel. The machine can cut to a depth of 20 ft., and to a width of 8½ ft. (or 12 ft. for special conditions).

The cutter chain is considered specially adapted for work in sticky material. The free movement of the buckets in swinging away from the chain at the head of the ladder tends to dislodge any clogged material, while each bucket passes across a scraper which positively removes any material adhering to it. The excavated material falls from the buckets upon a short transverse conveyor, which delivers it to an inclined belt conveyor discharging the material at the desired distance from the trench. Where the material can be used at once for backfilling, a longitudinal conveyor at the side of the trench may convey the material to the proper point for backfilling. Another special feature is the use of a section of trench bracing attached to the machine and trailing behind the ladder frame. This consists of a pair of stringers or wales with cross braces. It enables the side sheeting to be kept close up to the face of the work; thus providing against caving of the sides of the trench

immediately behind the ladder, where the ordinary trench bracing cannot be placed.

The tractor is a four-wheeled car, having wide-tired wheels set within the line of the side sills. The rear wheels are 5 ft. diameter and 2½ ft. wide, with a driving rack riveted to the inner face of each tire. A pinion gearing with each rack provides for the propelling of the machine, and the rate of feed or advance can be regulated as required. The front wheels are 3 ft. diameter, with tires 1½ ft. wide. Power for the excavating, conveying and propelling apparatus is provided by a four-cylinder gasoline engine of 100 HP. The total weight of the machine is 30 tons.

This excavator is the invention of F. J. Monahan, of Joliet, Ill., who has built three machines and used them on his own contracting work. One of the machines has been used for seven miles of sewer trench at Dolton, Ill. On one piece of work, the machine excavated a 92-in. trench through material as follows: 18 ins. of macadam and stone, 4 ft. of sand, 4 ft. of quicksand, and 4½ ft. in clay, the total depth being 14 ft. The machines are now being introduced by the Marsh Co., Old Colony Building, Chicago.

**The Fairbanks Dry-Land Dredge.**

Ditches for land drainage work are frequently excavated by what are known as dry-land dredges or walking-dredges which travel on the more or less solid ground and excavate the ditch behind them as they advance. The excavating apparatus is usually of the dipper-dredge type, but as the ground is very generally soft and wet special means must be provided to support the machine. One of the latest of these self-propelling dry-land dredges has special features both in its excavating and supporting appliances, as is shown by Fig. 2.

The machine has steel truss side frames, carrying a steel-frame floor upon which is mounted the machinery. The floor or platform is 40 × 12 ft., and has four 12-in. I-beams 40 ft. long which support the platform and machinery. This structure is not carried upon wheels, but is supported by four "caterpillars" or endless traveling platforms, composed of chains traveling over sprocket wheels and carrying a series of transverse planks. These caterpillars give a bearing area of about 250 sq. ft., equivalent to about 1 sq. ft. for each 400 lbs. of load, which is sufficient to carry the machine on soft ground.

At the rear of the platform is a steel mast, to the foot of which are attached two booms. The hoisting boom is supported by a topping lift in the usual way, and has sheaves for cables leading to sheaves on a rocking frame which is pivoted at the head of the second boom and carries the excavating bucket. The heel of this second or lower boom straddles the hoisting boom. The bucket is raised and lowered by raising and lowering the boom to which it is attached; when it is raised, both booms are swung laterally to dump the load. The cut is made towards the machine, and the machine keeps ahead of the excavation. The back of the bucket is movable, and by operating the backing line this is pulled through the bucket so as to act like a scraper and ensure the clean dumping of the contents. This feature is specially desirable where the machine is excavating sticky material. The bucket is of 1 yd. capacity.

It will be seen that the bucket or dipper is pivoted at the end of a boom of variable radius, and is operated by two cables which are attached to struts on the bucket frame. One of these struts extends forward, and to this is attached the dumping line; the other extends backward, and carries the hoisting line. The bucket is filled and hoisted by means of this line, which draws the bucket towards the machine and rotates it around its pivot in the head of the boom. When at the proper height, the load is swung to either side by cables attached to the sides of the boom. To dump the bucket, the hoisting line is released, and the dumping line hauled in, the weight of the load causes the bucket to swing back, overhauling the slack hoisting line. At the same time the back of the bucket is held by the bridle cables attaching it to the boom, so that it automatically scrapes the material from the bucket as described above.

No spuds or anchors are required, as the wide base of support and the distribution of the weight provide ample stability in swinging the booms. On the roof of the main housing and just behind the mast is the operator's cabin (not shown in the cut), from which all movements are controlled. Power for excavating and propelling is furnished by a 40-HP. gas engine with belt drive. The speed in traveling is about two miles an hour. These machines were designed and are built by the Fairbanks Steam Shovel Co., of Marion, O.

## Annual Convention of Idaho Society of Engineers.

Reported by S. D. CLINTON.*

The second annual convention of the Idaho Society of Engineers was held at Twin Falls, Feb. 16 to 18. About seventy members were in attendance.

PAPERS.—Twin Falls being the center of the largest irrigation district of the United States, most of the subjects dwelt on were irrigation problems. The first paper presented was by Mr. Don. H. Bark, U. S. Irrigation Engineer in charge of investigations in Idaho, on "The Duty of Water as Applied to Different Soils and Crops." This lecture was illustrated with charts and specimens grown and gave the results of the experiments on 27 tracts of land in various parts of the state.

Mr. Zenas N. Vaughn, of Boise, gave a paper on "Installation and Capacity of Reinforced-Concrete Siphons" and described in detail the construction of a 30-in. siphon which he built last year near Boise.

Mr. E. V. Berg, of Twin Falls, read a paper on "Pumping Water for Irrigation," which was followed by a description of the Minidoka plant by Mr. Barry Dibble, Electrical Engineer on the U. S. Reclamation Project at Minidoka.

In an able paper on "The Conservation of the Waters of the State," Mr. D. G. Martin, State Engineer, showed that while there are now 3,000,000 acres under irrigation, or under proposed projects, with efficient conservation and a high duty imposed on the water, fully twice as much land could be made productive.

Mr. R. S. Cookinham, of Wendell, read a paper on "Laying Out a Canal for a Given Acreage." Owing to lack of time a paper by Mr. A. M. McPherson on "Earth Dams," and one by Mr. F. W. Hanna, U. S. Project Engineer, on "Losses in Canals and Methods of Prevention," were read by title. These will be published, along with the other papers presented, in the Society Journal.

VISITS TO ENGINEERING WORKS.—Although the weather was pretty cold, about thirty members took the trip to the Great Shoshone and Twin Falls Water Power Co.'s Plant at Shoshone Falls in the afternoon. The five mile drive to the head of "the Grade" was made in carriages, and after viewing the grandeur of the Snake River Canyon, which is 2,000 ft. wide and 700 ft. deep, the party walked down to the ferry which crosses the river before it plunges 212 ft. to the level below.

Jake Fritz, who planted all the sage brush and dug the Snake River Canyon, explained to the boys how the Falls happened to be there. He said when he was planning the work, he hired a couple of parties of engineers to stake it out, and when they met at this point, their levels didn't check by 212 ft., so he "put in the Failsr and let it go at that."

On Sunday 41 members took advantage of a special free train furnished by the Oregon Short Line Railroad to make a visit to the Salmon River Dam. The train ran to Rogerson, the present end of track on the branch which traverses the 80,000-acre Twin Falls-Salmon River Irrigation Project, and which eventually will be extended to connect with the Southern Pacific in Nevada. From there we drove seven miles to the dam, and for three hours inspected one of the best pieces of engineering construction in the state.

The dam is practically completed and stands 224 ft. high from the lowest point in the lava rock foundation; it contains over 150,000 cu. yds. of concrete and several tons of steel trestle from which the concrete was dumped and left in place, although it was not figured as a reinforcement.

The outlet tunnel is 100 ft. above the bottom and 40,000 acre-feet of water is stored before any is available. The first tunnel is 1,300 ft. long, then comes an open channel 2,200 ft. long, which has a 400-ft. spillway and then 2,200 ft. of tunnel to the head of the main canal. The concrete lining in the second tunnel is almost completed and the job will be finished in about 30 days.

Mr. Horn, the constructing engineer, was not able to be present, but we were well taken care of by his assistant, Mr. Gilbert.

During the convention the society was invited by Mr. Dan White, Superintendent for the Warren Construction Co., and Mr. Mull, City Engineer, to inspect the bitulithic pavement in Twin City. President Utter selected the spot and Mr. White secured some laborers, who proceeded to cut the pavement. Four square feet of the pavement were removed. This was soon broken up and carried away as souvenirs.

BUSINESS PROCEEDINGS.—The reports of officials showed a prosperous year, reflected in part by an increase in members from 60 to 150. The membership requirements were raised and the initiation fee doubled.

No action was taken in regard to licensing engineers, as Idaho already has a law for licensing surveyors, and it was thought the legislature would take no action unless it was urged by the Society, and even then it was thought the chances would be small of having a bill passed just as the Society wanted it.

The Good Roads Bill now before the Legislature was heartily endorsed.

Boise was selected as the place for the next annual meeting.

The following officers were then elected: President, Darwin A. Utter, Surveyor General State of Idaho; Vice-President, State Engineer D. G. Martin; Secretary, Edmund M. Blake, Boise; Treasurer, Charles H. Mull, City Engineer, Twin Falls.

An entertainment given by the ladies of Twin Falls and a well-attended banquet were features of the convention.

*Chief Engineer, Portneuf-Marsh Valley Irrigation Co., Downey, Idaho.

STEEL MAIL CARS FOR THE PENNSYLVANIA R. R. have recently been built by the Pressed Steel Car Co., of Pittsburg, Pa. They are to be used on the lines west of Pittsburg, Pa. The cars are of the stub-end type with monitor roofs. Even the window sashes and doors are of steel, as are also the letter and paper cases, pouch racks, tables and fittings. The length over buffers is 174 ft. 9¾ ins. (54 ft. 9 ins. c. to c. of trucks) and the maximum width (at the eaves) is 9 ft. 11½ ins. The height from rail to top of roof is 14 ft. ½-in., and from rail to floor 4 ft. 4 ins. The body of the car alone weighs 83,860 lbs. and the total weight with the trucks is 128,000 lbs.

Six-wheel trucks are used with 5 × 9-in. journals and 36-in. rolled steel wheels. The main framing of the car is composed of two 18-in. channel-section center sills and two 5-in. channel side sills, tied together by pressed steel cross-bearers and 6-in. channel diaphragms. The side posts are pressed-steel channels and the corner posts are 4-in. Z-bars. The end door posts are 12-in. I-beams. The belt rail is a 4 × ½-in. steel bar.

The outside sheathing is ⅛-in. steel, while the inside lining is of 1/16-in. steel with a composition covering glued to the back of the sheets. The upper-deck, or monitor, roof is made of .08-in. steel and the lower-deck roof is of .062-in. steel. The ceiling inside is lined with a patent composition board. The "Carbolith" floor, 1½ ins. thick, is laid on No. 16 gage corrugated steel. The only thing lacking for a reasonably fireproof construction seems to be the use of wire-glass windows.

The construction of these cars is especially interesting in connection with certain provisions included in an act passed by the recently adjourned Congress. This act provides for the gradual elimination of wooden railway post-office cars for use in trains of which most of the cars are of steel. No new cars, it is provided, are to be accepted for the postal service in this class of trains unless constructed of steel or at least with steel underframes; and within five years the transition to steel, or steel-underframe, cars is to be completed and no wooden mail cars are to be used at all in the same train with steel passenger cars, after the expiration of that period.

# The Substructure of the Municipal Bridge Over the Mississippi River at St. Louis, Mo.*

By S. W. BOWEN,† Assoc. M. Am. Soc. C. E.

The Municipal Bridge now under construction at St. Louis crosses the Mississippi River about a mile below the celebrated Eads Bridge. The new bridge is designed to carry both railway and highway traffic; provision is made for two railway tracks, two trolley tracks on a 30-ft. paved roadway and two 6-ft. sidewalks. The river crossing is a double-deck structure, carried on pneumatic foundations sunk to bed rock; the upper deck is for highway and the lower deck for railway traffic. The general design and dimensions of this part of the structure are shown in Fig. 1.

The approaches consist of steel viaducts on concrete pedestals, and end in earth fills between concrete retaining walls. The railway and highway approaches on each side are carried side by side for about 0.4-mile from the channel spans, and beyond these points they diverge. The maximum grade on the railway approach is 1.38%, while that on the highway is 4.24%; these grades extend only over short distances. The total length including the steel railway approaches is about 2¼ miles, while the length over all (including the retaining walls) is about 2½ miles.

The substructure of the river crossing consists of four masonry piers, founded by pneumatic caissons on bed rock. The span lengths and clearances above high water were made to conform with the requirements of the U. S. War Department. The rock dips rapidly toward the east (as shown in Fig. 1), and pier No. 4 is one of the deepest piers ever sunk by the pneumatic process.

On July 28, 1909, the contract for the substructure of the river spans was awarded to the Missouri Valley Bridge & Iron Co., of Leavenworth, Kan., and shortly thereafter the contractor began laying out a material yard on the Illinois side of the river. On Dec. 20, 1909, the cutting edge for the first caisson (that of pier No. 4), was riveted up.

As the ground at the sites of piers (1) and (4) is above the ordinary stage of the river, the caissons for these piers were constructed on blocking at the sites, and excavation was started by hand. The caissons for piers (2) and (3) were built in a pontoon, from which they were launched and towed to position. The work of sinking was begun in the following order: piers (4), (1), (3) and (2), one pier being sunk at a time. Owing to high water, pier (4) was temporarily abandoned when a few feet above bed rock, and work was started on pier (1), which was landed and sealed before returning to pier (4), the next one sealed. Piers (3) and (2) were sealed in the order named.

The construction of the caissons and surmounting cribs is shown in Fig. 2, and needs no detailed description. The caissons contain comparatively little timber, the necessary strength being obtained by reinforcing the concrete filling with steel rods.

The pontoon from which the two caissons were launched, was about 40 × 100 ft. in plan and had sides 8 ft. high. The sides and bottom were built of 4-in. plank, braced and calked. The pontoon was divided into halves lengthwise; the two parts being bolted together from the inside. The pontoon possesses some advantages over "ways" as a means of supporting and launching caissons. It can be used on any shore and in places where "ways" would be difficult to construct and maintain. Where a pontoon is used, work on the caisson is not interfered with by the rise or fall of the river. This is specially important on rivers like the Mississippi where there is a continual change of stage; sometimes amounting to several feet in 24 hours. The estimated cost of the pontoon in this case was about the same as that of "ways."

After the caisson was built up to a height of about 17 ft. above the cutting edge, and the calking of the air chamber and friction planking was completed, the halves of the pontoon were unbolted, plugs removed from holes in the bottom, and water allowed to enter. The pontoon slowly filled and sank, the buoyancy of the timber holding the two halves in position against the cutting edge of the caisson. One half of the pontoon was anchored to clusters of piles, and a tug pulled the other half from under the caisson, which settled into the water clear of the pontoon. This is shown in Fig. 3. The caisson, now floating free, was built up to the full height, and towed by three tugs to the site, where it was anchored in approximate positions to clusters of piles arranged as shown in Fig. 4. The pontoon was towed to shore and the halves were bolted together in readiness for the next caisson.

The river bed around the upstream end of the caisson and for some distance down each side, was first covered with sacks of sand, to prevent the bottom from scouring out from under the caisson. The sacks were deposited through a section of supply shaft 24 ins. in diameter and long enough to reach the bottom. Concreting was now started, and the caisson gradually sank as the filling progressed, until the river bed was reached. Air was then turned on, the caisson raised slightly, moved into proper position by means of the cables, and the air released, allowing it to settle to the river bed. In placing the caisson, care was taken to bring its axes parallel to the true axes, although they might not exactly coincide. As the tendency of the caissons was to creep upstream and toward the east, they were set slightly to the south and west of true position. Any shifting necessary while sinking, was accomplished by listing the caisson in the desired direction. After the caisson had settled well into the mud, the anchorage and adjusting cables were released, air was turned on and the first gang entered the air chamber. They leveled up the caisson and brought it to a uniform bearing by excavating the material from under the cutting edge at the high points.

Owing to the low stage of the river when sinking was started on piers (2) and (3), there was but 15 to 17 ft. of water at the pier sites. The caissons therefore grounded before sufficient concrete could be placed to render them rigid, and great care was required to prevent them from warping. Levels were taken several times a day with a view to detecting this warping; when discovered, it was corrected by loading the diagonally opposite high corners, and excavating under them until the four corners returned to a plane. After the caisson was well filled, no further trouble was experienced from this source.

Sinking was carried on continuously and concreting was kept up during the day time until the caisson and crib were filled nearly to the top of the latter. A timber cofferdam was then started on top of the crib and built up as the sinking progressed. No masonry was laid until bed rock was reached and sealing completed, thus enabling the masonry to be started in the correct position. The surface of the concrete was kept somewhat below the top of the crib in order to provide for the possibility of finding rock at a higher elevation than that shown by borings previously made at each site.

As the rock was approached, frequent soundings were made in the air chamber. When but 2 or 3 ft. of sinking remained, the slope of the rock was accurately determined by soundings taken at close intervals all around the caisson, as close to the cutting edge as the slope of the roof would allow. The caisson was then tilted

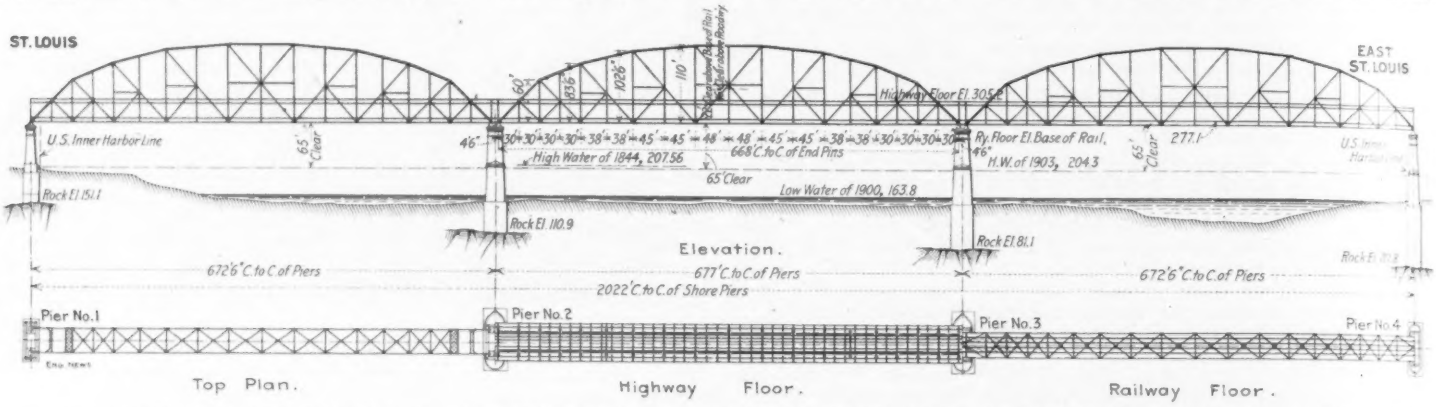


FIG. 1. ELEVATION AND PLAN OF THE RIVER PORTION OF THE MUNICIPAL BRIDGE OVER THE MISSISSIPPI RIVER, AT ST. LOUIS, MO.

*This new bridge, which is being built over the Mississippi River by the city of St. Louis, Mo., is of special interest on account of the great length of its three truss spans over the channel (the longest truss spans ever built) and also as being a double-deck structure for railway and highway traffic. The project for this bridge originated in the desire of the city to offer railways a direct communication between eastern and western lines, independent of the two railway bridges (the Eads bridge and the Merchants bridge) which are controlled by the Terminal Railway Association of St. Louis. The third bridge (McKinley bridge) is for electric railway and highway service, although in its design provision was made for future alterations to adapt it to steam railway traffic. The following particulars as to the history and design of the city or Municipal bridge (commonly known as the "free bridge") are taken from a paper read at the annual meeting of the Illinois Society of Engineers and Surveyors (at East St. Louis, Ill., Jan. 26) by Mr. Charles W. Talbert, Assistant Engineer of the Board of Public Improvements, St. Louis, Mo. A very complete description of the substructure work and superstructure of the McKinley Bridge was given in Engineering News, Jan. 6, and July 28, 1910.—Ed.

The original ordinance authorizing the issue of bonds for the "free bridge" over the Mississippi River was passed by the Municipal Assembly of St. Louis on April 3, 1906. The election was held June 12, and an ordinance for the sale of bonds was passed on Nov. 26. In July, 1907, an ordinance was passed locating the bridge at (or near) the foot of Chouteau Ave.; it was vetoed by the Mayor (Mr. Wells) on Nov. 26, but passed over his veto by the Assembly on Nov. 27. On Dec. 18, 1907, the Board of Public Improvements was directed to prepare general plans for submission to the War Department. These provided spans and headway conforming to those of the Eads Bridge. They were forwarded on Sept. 10, 1908, but were rejected on account of objections made by river navigation interests. The War Department then stipulated (1) a headway clearance of 65 ft. above the high-water level of 1903, (2) a central span of about 650 ft.; (3) shore piers outside of the harbor lines. The second plans, providing for 677-ft. span and 65-ft. clearance were submitted on Nov. 30, and were approved by the War Department on Dec. 17, 1908. The location was below Chouteau Ave. on the west and below Pittsburg Dike on the east side.

In January, 1909, Boller & Hodge, of New York, were appointed the engineers. In May, a new location (above Pittsburg Dike) was submitted to the War Department, and was approved by it on May 20. Bids for the four river piers on this final location were opened July 27, 1909; and bids for the three channel spans on Nov. 16, 1909. The pier masonry from the crib to the coping is to be limestone, at $9.50 per cu. yd. The contract prices for the piers were as follows:

| | Per cu. yd. | Total. |
|---|---|---|
| Foundation work; below cutting edge. | $27.00 | $9,428 |
| Cutting edge to top of crib..... | 12.90 | 272,702 |
| Top of crib to coping..... | 9.50 | 158,454 |
| Coping and bridge seats..... | 1.90 | 19,251 |
| | | $459,836 |

†Engineer in Charge for Brenneke & Fay, St. Louis, Mo.

very slightly and allowed to settle slowly until the low cutting edge was landed on the side where the rock was highest. By doing this, any further slight settlement in coming to a bearing tended to level the caisson. The surface of the rock was then cleaned off, and all loose pieces removed preparatory to sealing. In general, the caissons landed along the west side and a portion of the north and south ends, the slope of the rock being downward toward the east, with local irregularities north and south. The rock was sufficiently uneven to give an excellent bond with the concrete.

No attempt was made to level off the rock so as to bring the caisson to a bearing throughout; but where depressions occurred, sacks of concrete were deposited on the rock and tamped under the cutting edge. A wall was thus formed inside of which concrete was deposited in the usual manner. Where the cutting edge and rock were not in contact, the distance between them was in general only a few inches (in no case more than 2 ft.), so that this sacking was readily accomplished, as follows: The sand was first excavated from under the edge for a space about the width of a sack. The sack loosely filled with concrete was then slid down a plank to the cavity and thrust out under the cutting edge, one end projecting entirely outside the edge. The water jet was then thrust under the sack and the sand washed out from under it, allowing the sack to rest directly on the rock. This process was repeated until a number of sacks had been placed on the rock. When necessary, a second tier was placed on the first and in some cases a third was added. In all cases concrete was thoroughly tamped under the shoulder of the cutting edge and the sacking was immediately followed by a bench of concrete carried up under the shoulders of the roof and well tamped.

In sealing, double gangs were used, working during the day only. Concrete was locked in through each material shaft, the lock being located at the extreme top of the shafts and being equipped with a hopper into which the concrete was dumped. The upper door of the lock was then raised, the lock equalized and the lower door dropped, allowing the charge of concrete to fall down the shaft to the air chamber. There it was shoveled back and tamped under the shoulders and roof of the air chamber. Toward the end of the sealing, only a small tunnel was left, connecting the main shaft and nearest material shaft. This was filled as full as possible with loose concrete by two men, there being no room to tamp; when no more concrete could be placed in this manner, the size of the cavity was measured and the men left the air chamber, closing the lower door and equalizing the entire shaft. Sufficient grout was then locked in to fill the cavity, plus about 100%. This was followed by a charge of about 1 cu. yd. of concrete and the sealing was completed. The concrete used in sealing was 1:2:4, with 1-in. coarse aggregate. Air was left on for 12 to 15 hours after sealing was finished in order to give the concrete time to set. It was then reduced at the rate of about 5 lbs. per hour.

The cofferdam was next pumped out, the main shaft unbolted just below the lock, and the shaft and lock hoisted out. The material locks were removed, together with the portions of shafts extending above the concrete. The surface of the concrete in the crib was then brought up to the proper elevation, the material shafts and the boxed space occupied by the main shaft were filled with concrete, the outline of the first course of masonry was laid out and masonry started.

Above the top of the crib the piers are faced with Bedford stone in 2-ft. courses, backed with concrete, of which there are two classes: 1:2:4 and 1:2½:5. The up-stream nosing stones and the coping and bridge seat stones are of Georgia granite. The stone was brought from the material yard in cars by a locomotive crane and loaded onto barges. Stones were handled at the pier by means of a floating derrick with a 90-ft. boom. The design of the two river piers is shown in Fig. 5, and Fig. 6 shows one of the shore piers completed.

The contractor's floating equipment consisted of (1) a pressure barge, on which were four boilers, three air compressors, dynamo, hospital lock, pumps, etc.; (2) a mixer barge for mixing and handling concrete; (3) a large derrick barge; (4) a derrick and pile-driver barge; (5) two cement barges; (6) the "hog house" barge; also a number of barges for sand, gravel, stone and coal. There was a steam tug for towing and a gasoline launch for ferrying. On land there was a 20-ton locomotive crane for handling material; also derricks, hoisting engines, etc.

The hospital lock, for use in treating cases of caisson disease, was equipped with bunks, an electric battery and medical supplies. An attendant was in charge, and the company's physician could be summoned at short notice. The treatment consisted first in the application of air pressure about equal to that in the working chamber, then in massaging, rubbing with liniment, and applying hot cloths and stimulants. In cases of paralysis, the battery was used. The air when released was let out slowly. The treatment given in the lock was found to be very effective in cases of paralysis, but sometimes gave only temporary relief to cases of the "bends."

The mixer barge was equipped with two derricks independently operated. One of these handled a 1-yd. clamshell bucket for transferring sand and gravel from barges to a double elevated hopper. This hopper discharged the material into separate measuring boxes, from which it was shot into the mixer, where the cement and water were added. The mixer dumped into a 1-yd. bucket handled by the other derrick, which deposited the concrete in the work. The capacity of this rig was about 300 yds. per day of 10 hours, with a crew of about 25 men.

On Jan. 12, 1910, when excavation for pier 4 was about to be started and while the caisson was still on blocking at the pier site, an ice gorge formed below the bridge; the river rose 10 ft. in a few hours and an enormous quantity of ice was forced onto the shore. The power barge, pontoon and several barges were carried about 200 ft. inland, the caisson was forced off the blocking and carried east and south nearly its own length. The derrick and hoisting engine at the pier was wrecked and a great deal of minor damage was done. The gorge broke the next day and the water immediately fell, leaving this mass

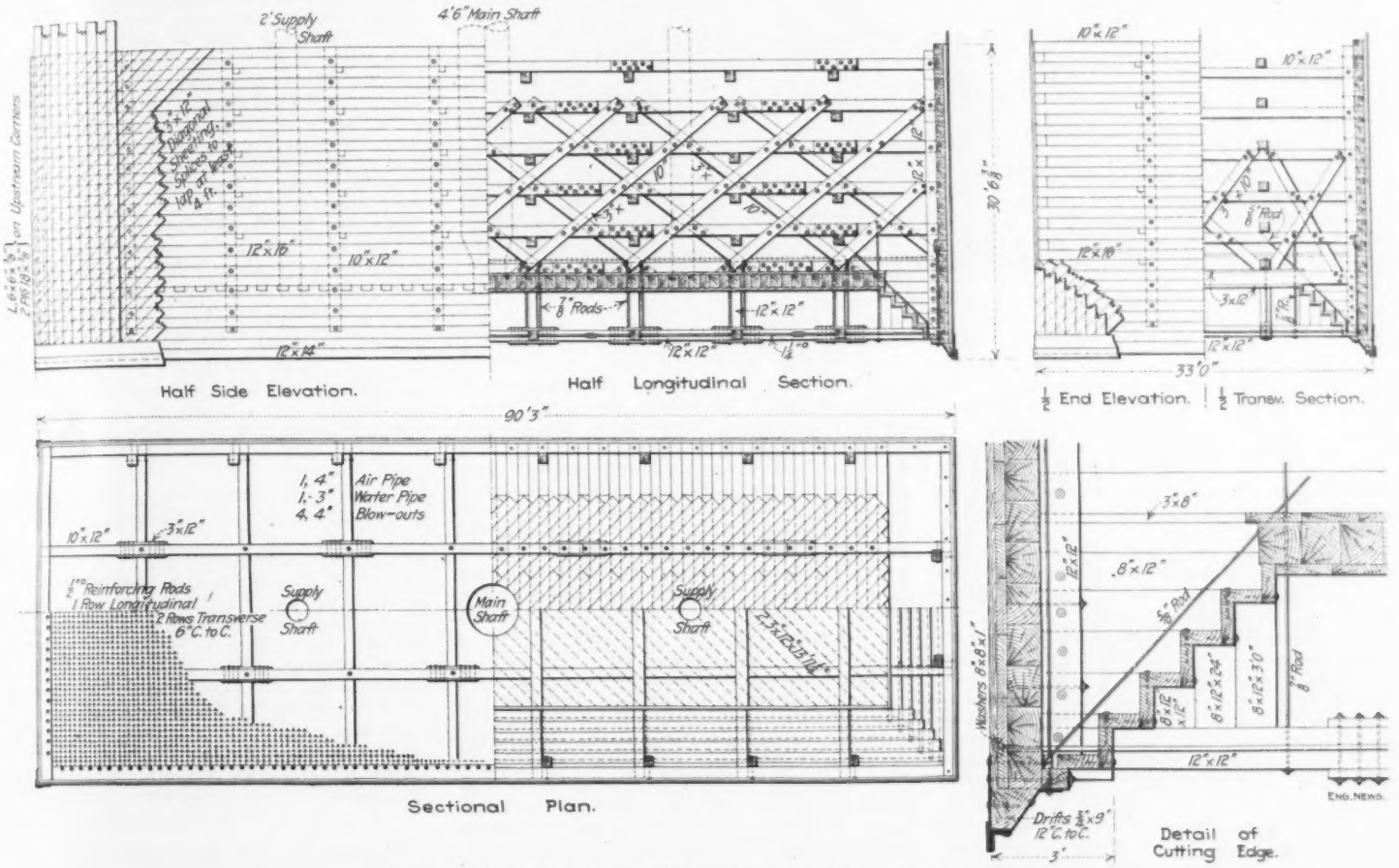


FIG. 2. CAISSONS FOR THE RIVER PIERS OF THE MUNICIPAL BRIDGE.

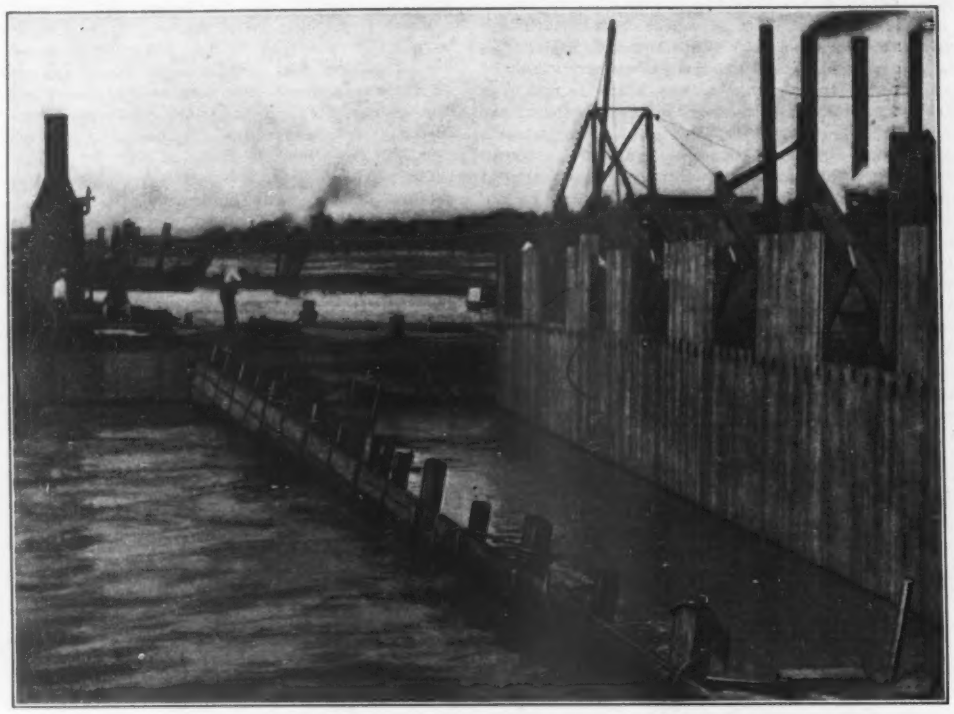

FIG. 3. LAUNCHING A CAISSON FROM THE PONTOON IN WHICH IT WAS BUILT.
(The pontoon was sunk, and one half towed away, leaving the caisson afloat. At the left is the top of the pontoon being towed away; at the right is the side of the caisson.)

of ice and wreckage on the shore. The contractor at once set about clearing the wreckage; the power barge was jacked up and placed on blocking, where it was left until spring. The pontoon was left until floated by the next rise of the river, while the barges were moved back to the river and the caisson jacked back into position. Excavation was started on Feb. 21, 1910, after a delay of over a month.

In sinking the caisson for pier 4, a number of barges were encountered. These had been towed into the cove, scuttled and sunk from time to time and were piled on top of each other three or four deep. Progress through this mass of wreckage was necessarily slow, as 6 × 12-in. and 12 × 12-in. oak timbers had to be cut off and passed out through the locks. Light charges of dynamite were used to break up the worst of the wreckage. When about 5 ft. above bed rock (in the same piers) a mass of boulders and gravel mixed with sand was encountered. These boulders ranged from the size of a baseball to about 1 cu. yd. They were without exception rounded and worn smooth. Most of these boulders were locked out through the material shaft, being hoisted by the locomotive crane. Those left in the air chamber were bedded in the concrete. A progress of 3 ins. per day was considered very good through this material. Rock was finally reached after much trouble. The high pressure under which the men worked, and the consequent shortening of the shifts, added greatly to the difficulty and expense of the work. At one time the pressure in the air chamber reached 50 lbs. per sq. in., which is about the limit of human endurance.

When pier 3 had nearly reached rock, the cofferdam sprung a leak and filled. After sealing was finished, a diver was sent down to locate the leaks. They were then battened from the outside with 1-in. boards and the boards covered with a strip of canvas securely battened down. All this work was done by a diver standing on the river bottom. After this the cofferdam was pumped out without difficulty and the masonry started.

Aside from the above, no unusual difficulties were met with and the sinking was completed in good time. The work on each pier is shown in the accompanying table (detailed lists of progress being omitted.—Ed.). The rate of progress in sinking piers 1, 2 and 3 is in striking contrast to that of pier 4. In sinking those first named, no obstructions were encountered. The material passed through was, in general, clean river sand with some gravel, and good progress was made. The best sinking record made on this work was on pier 3, being 34 ft. in one week of 7 days, with a maximum of 5 ft. 2 ins. in 24 hours. The size of the caisson was 33 × 90¼ ft., requiring at least 110 cu. yds. of material to be blown out for each foot sunk. The caissons except for pier 4, followed down by their own weight, until but a few feet above rock.

| | Total sinking (ft.) | Total days.* | Ave. ft. per day. |
|---|---|---|---|
| Pier 1 | 50.27 | 67 | 0.75 |
| Pier 2 | 48.14 | 29 | 1.66 |
| Pier 3 | 77.90 | 40 | 1.95 |
| Pier 4 | 108.67 | 161 | 0.68 |

*Including lay-offs.

### Triangulation.*

While preliminary construction work was going on, the triangulation system was being laid out. Base lines were located on each side of the river; their position being determined largely by certain railway tracks along the St. Louis levee, and by the configuration of the east shore. As shown on Fig. 4 the west base line is about equally divided by the bridge tangent, while the east base line lies wholly north of this line. It was not practicable to extend the east base line to the south of the bridge tangent, owing to the fact that the Pittsburg Dyke is much higher than the surrounding ground and would have prevented an uninterrupted sight from one end of the base line to the other. Levels were run across the Eads Bridge connecting the U. S. bench marks at each abutment, and complete circuits were run down each side of the river, establishing benches near piers 1 and 4. Later, levels run across the river on the piers checked the last named benches within 0.03 ft.

The atmospheric conditions along the St. Louis River front are far from being ideal; especially in the winter. On some days smoke and fog hung over the water so thick that it was impossible to see from one bank to the other. The work was further complicated by the movement of trains and wagons across the west base line, which lies along the top of the levee. In spite of these annoyances, the base line and angles were all measured with great care and the results obtained from the various triangles, after making the necessary corrections and adjustments, were highly satisfactory. The laying out of the triangulation system was done by Mr. Philip Aylett.

During January, 1910, the river was frozen over for several days, an unusual occurrence. Advantage was taken of this to locate the centers of piers 2 and 3 on the ice by measuring along the bridge tangent. A transit was set up at these centers and range lines thrown to each shore. These range lines were then rigidly tied in with the triangulation system by measuring the distance to each intersection point and the angle at each point between the range and base line. After this was done, the intersections of the two pairs of range lines with the bridge tangent were carefully computed and found to be small triangles instead of points.

Piers 2 and 3 were located by the intersection of three lines, the bridge tangent and two range lines; the latter intersected at nearly 90°. Pier 3 was located from the east side of the river, while pier 2 was located from the west side. Targets were placed on buildings at the west ends of the lines for pier 3 and on high timber tripods at the east ends of the lines for pier 2. As the distance from the instrument station to the target was three or four times the distance from the instrument station to the pier, any error in setting on the target would be divided by three or four at the pier.

As the caisson and crib was built up, the center lines were carried up each of the four sides by striking arcs with steel tapes from each corner. By means of these center lines, the axes of the caisson were established and their intersection (or the "built center" of the caisson) was marked on a plank from time to time as the caisson was built up. The intersection of the range lines with the bridge tangent was struck on this plank every morning and the position of the "built center" with respect to the axes through the true center thus established was recorded.

Levels were taken daily on nails at the four corners of the caisson whose distance above the cutting edge had been obtained by measuring with a steel tape. From these levels, the elevation of each corner of the cutting edge and the list of the caisson in each direction was obtained. From the position of the caisson at the top, and the list, the position of the cutting edge with respect to the true axes was computed. The information thus obtained was entered in the daily report.

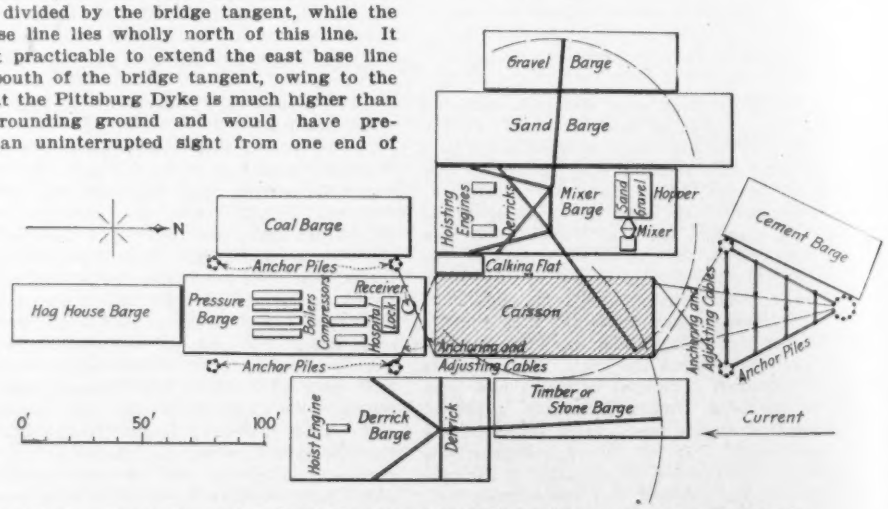


FIG. 4. PLAN OF ANCHORAGES AND CONSTRUCTION PLANT AT CAISSON.

*The triangulation methods at the McKinley Bridge, at St. Louis, were described in our issue of Jan. 6, 1910.—Ed.

After the masonry of piers 2 and 3 was well above the water the range lines were struck on each pier with great care. The small triangles formed by the intersection of the three lines were adjusted to the computed size and the pier centers established. Angles were then read to each pier center from the north ends of both base lines. These measured angles were then compared with the calculated values with which they were found to differ from 2" to 9". The pier centers were then shifted a slight amount in the required direction and the angles re-read. This second reading gave results so close to the computed values that this location of the centers was taken as final.

As a rough check on the spacing of the piers, right angles were turned at each pier center, with the bridge tangent, and points were established on the upper deck of the Eads Bridge. Each right angle was turned 12 times, two men being at the instruments, turning alternate angles. The average of the twelve points was taken and a mark established on the sidewalk planking. In establishing these points, a cloth-covered target 30 ins. square was fastened to a rod with a plumb bob attached. The angle between the two structures, and the distances between pier centers established on the sidewalk, were then carefully measured. The measured distances were corrected for temperature and grade and finally multiplied by the cosine of the angle between the two bridges. The results obtained are given below. As

| | West span, ft. | Center-span, ft. | East span, ft. |
|---|---|---|---|
| Measured distance..... | 672.50 | 676.97 | 672.62 |
| Plan distance..... | 672.50 | 677.00 | 672.50 |

the distance between the two bridges is about a mile, the results obtained are surprisingly close to the plan dimensions; much closer, in fact, than was thought possible when this method of checking was determined on.

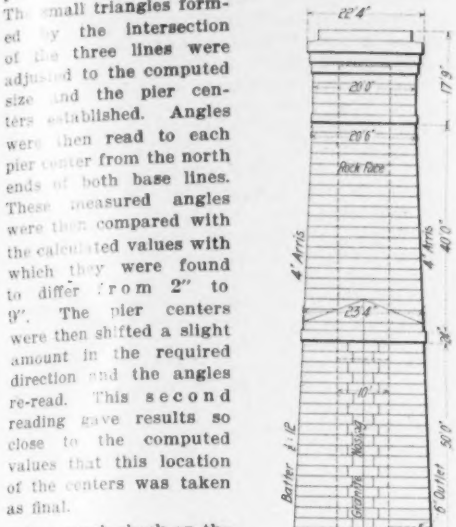

Fig. 6. Pier No. 1 for the Municipal Bridge (Shore Pier on the St. Louis Side).

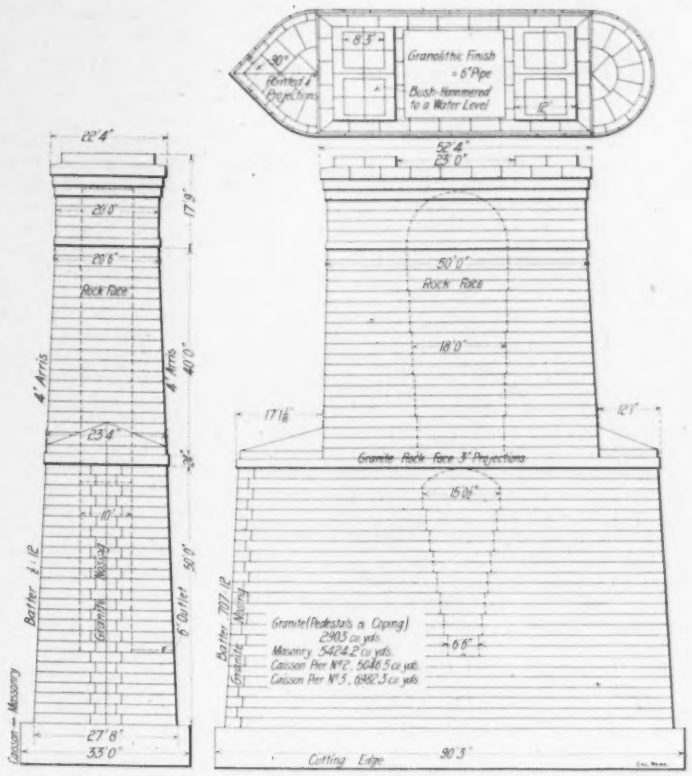


FIG. 5. CHANNEL PIERS OF THE MUNICIPAL BRIDGE, ST. LOUIS, MO.

Foresight targets were now placed on the side of each pier, one on each range line and one on the bridge tangent, and the centers carried up from course to course by sighting on these targets from the instrument stations on shore. As these centers were established on the forms of the central void of the pier, they could also be carried up from course to course by plumbing. This was done as a check on the intersection of range lines. For getting the elevation of each course, a bench mark was established on the forms of the central void by leveling from shore and elevations carried up by means of a steel tape.

On Dec. 31, 1910, work on the piers was stopped for the winter and was not resumed until Feb. 27, 1911. The present state of the work is as follows: Pier 1, completed; piers 2, 3 and 4, completed below water, and masonry laid for about 30 ft. above low water. Piers 3 and 4 will be finished first, to allow the erection of the east span after the high water, which usually subsides early in June.

The cost of the four piers complete, exclusive of engineers' fees is about $470,000, or an average of about $12 per cu. yd.

The structure was designed by Boller & Hodge, Consulting Engineers, of New York, who were appointed by the President of the Board of Public Improvements of the city of St. Louis. Local matters are under the direction of Brenneke & Fay, of St. Louis, as Resident Engineers, the writer being Engineer in Charge.

**REFUSE DESTRUCTORS** of the British type are now under construction or contract as follows: At San Francisco, Cal., two 120-ton plants, one for the Islais Creek district, and the other for the North Beach district, the latter to be with provision for an increase to 360 tons daily capacity; at New York City, a 90-ton plant for the Clifton district; at Seattle, Wash., a duplicate of the destructor built there a number of years ago; at Montgomery, Ala., a plant, capacity not stated, and at Havana, Cuba, a particularly large plant having a 24-hr. capacity of 500 tons, made up of four 125-ton units. The two San Francisco plants will be composed of 60-ton units, and the Clifton district plant for New York City, of 45-ton units. The new destructor at Seattle will be of the Meldrum type, and all of the others mentioned will be of the Heenan and Froude type. All of the plants will make use of high temperatures. British types of destructors, as many of our readers know, are already in use at Westmount, a suburb of Montreal, P. Q.; at Seattle, Wash.; at West New Brighton, New York City, and at Milwaukee, Wis.

## The Increase in the Size of the Corps of Engineers, U. S. Army.

As an additional paragraph to the annual rivers and harbors bill, the following passage relating to the increase in the number of officers in the Corps of Engineers, U. S. Army, became a law by the signature of the President on Feb. 27, 1911.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled; That the Corps of Engineers of the United States Army is hereby increased by 5 colonels, 6 lieutenant colonels, 19 majors, 17 captains, and 13 first lieutenants. The increase in each grade hereby provided for shall be extended over a period of five years as nearly as practicable, and the original vacancies hereby created in each grade shall be filled by promotion from the next lower grade in accordance with existing law: Provided, That officers of the Corps of Engineers, when on duty under the Chief of Engineers, connected solely with the work of river and harbor improvements may, while so employed, be paid their pay and commutation of quarters from the appropriations for the work or works upon which they are employed: Provided further, That whenever it shall be necessary, in order to properly prosecute works of river and harbor improvement, the Chief of Engineers is authorized to detail for duty in charge of river and harbor districts or as members of boards of engineers any assistant engineers in the employ of the Engineer Bureau of the War Department. Vacancies in the grade of second lieutenant in the Corps of Engineers shall hereafter be filled, as far as may be consistent with the interests of the military service, by promotions from the Corps of Cadets at the United States Military Academy: Provided, That vacancies remaining in any fiscal year after the assignment of cadets of the class graduating in that fiscal year may be filled from civil life as hereinafter provided: And provided further, That the proportion of any graduating class assigned to the Corps of Engineers shall not be less than the proportion which the total number of officers authorized at date of graduation for that corps bears to the total number of officers authorized at same date for all branches of the Army to which cadets are eligible for promotion upon graduation, except when such a proportionate number is more than the number of vacancies existing at date of graduation plus the number of retirements due to occur in the Corps of Engineers prior to the first day of the following January. To become eligible for examination and appointment, a civilian candidate for the appointment as second lieutenant must be an unmarried citizen of the United States between the ages of twenty-one and twenty-nine, who holds a diploma showing graduation in an engineering course from an approved technical school, and is eligible for appointment as a junior engineer under the Engineer Bureau of the War Department. Selection of eligible civilians for appointment, including term of probation, shall be made as the result of such competitive examination into the mental, moral, and physical qualifications, and under such rules and regulations as shall be recommended by the Chief of Engineers and approved by the Secretary of War.

This law is in effect the same as the separate act which was passed by the House of Representatives at the second session of the 61st Congress (adjourned June, 1910), but which was never passed by the Senate (Engineering News, May 12, 1910, p. 564). The main difference is that the older act provided for twelve officers, distributed definitely among the various grades, to be added in each of the five next succeeding years, instead of merely specifying, as does the present law, that the increase of 60 officers should be extended over the next five years "as nearly as possible." The act of 1910 also included the provision that the President might "detail any army engineer to the supervision or inspection of any engineering work or works of construction carried on by the government." As the main purpose of this clause, i. e., the supervision of the Reclamation Service by the army engineers, was provided for at the last session of Congress, by a separate Act, it was unnecessary to include it in the present law.

The present strength of the Corps of Engineers, as provided by the law of April 23, 1904, is 188 officers, so that the maximum allowed strength at the end of the five-year period provided by the new law, will be 248 officers. There is no immediate prospect of increasing the roster at the U. S. Military Academy, so it is possible that the demand for line officers may be so great that one or two engineer officers may be appointed next year from civil life.

## Some New Tests of Built Steel Columns.

Two valuable sets of column tests have been published recently. They add materially to our information on the strength of steel columns. A summarized statement of methods and results is therefore given here, although for a full statement we must refer to the originals, which are too extended to reproduce.

### Tests of Five Large Columns.

Five compression members of a railway bridge were tested about a year ago by the Engineering Department of the Pennsylvania Lines West of Pittsburg. Mr. J. E. Howard, then of Watertown Arsenal, and Mr. C. P. Buchanan, Assistant Engineer of Bridges of the railway, conducted the tests, Mr. J. C. Bland, Engineer of Bridges, being in general charge of the work.* The five columns were substantially alike; their lateral dimensions were about 20 × 30 ins., and the cross-sectional area of each was 90 sq. ins. Thus they are *the largest columns ever tested to destruction.*

The columns were made up of two ribs 30 ins. deep spaced 20⅝ ins., laced together by two lines over the plates, of 2½ × ⅜-in. lacing. Each rib was made of an outside plate 30 × 11/16-in.,

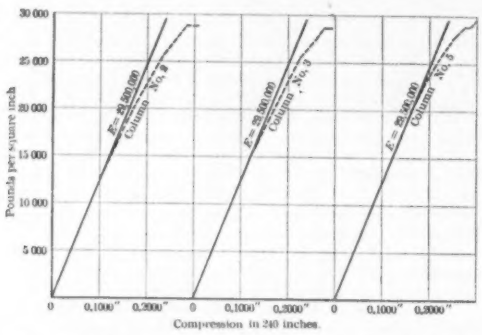


Fig. 1. Stress-Strain Curves from Compression Tests of Three Large Built Steel Columns.

(Phoenixville tests of Steubenville Bridge members. Each column had a cross-section of about 90 sq. ins., and was 36 ft. 5 ins. long. The measurements refer to the middle 20 ft. The dotted line is the actual curve for the column, while the straight full line represents proportional shortening at the rate of modulus E = 29,500,000 lbs. per sq. in.)

an inner plate 17½ × ⅝-in., and two inner edging angles 6 × 6 × ⅝-in., the lacing being riveted to the outside of the projecting legs of these angles. Transverse plate diaphragms about 6 ft. apart served to give additional lateral rigidity. While the corresponding columns in the bridge had riveted connections, the test columns were fitted with pin ends, the pin being 10 ins. in diameter and set parallel to the plane of lacing. The required pin-bearing area was secured by one ⅝-in. inside pin-plate and one ½-in. outside pin-plate on each rib. The member was assembled with ⅞-in. steel rivets driven in sub-punched and reamed holes.

The columns were tested in the 1,200-ton hydraulic testing-machine at Phoenixville, Pa., but one column was given a preliminary loading in the Emery machine at Watertown Arsenal for check purposes. Extensometer readings were taken (1) on the middle 20 ft. of the length and on the full length of the member; (2) on various 10-in. gage lengths, mainly at and near the ends of the members, in part on the pin-plate and in part on the web or angles of the shaft of the member; (3) on lattice bars; and (4) transversely, both across the width of the web-plate and across the latticing, that is, from rib to rib.

The loading was carried to failure in three cases; in the other two columns failure was not attained. Of the columns which failed, one buckled in the web-plates, while two failed by local bulging in front of the pin. Mr. Howard concludes, however, that all five columns possessed a true ultimate strength approximately equal to that of the one column which failed in the body. The results are shown in Table I.

*See the paper "Some Tests of Large Steel Columns," by J. E. Howard, in "Proceedings of the American Society of Civil Engineers," February, 1911, pp. 186-204. The paper is to be presented before the society April 19, 1911.

TABLE I.—FAILURE TESTS OF FIVE BRIDGE COLUMNS, P. C. C. & ST. L. RY., STEUBENVILLE BRIDGE.

(Tested at Phoenixville, Pa., by J. E. Howard and C. P. Buchanan.)

| Col. No. | Section area, sq. ins. | Length, ft. | Length, ins. | Value of $l/r$ | Maximum Load Applied. Total. | Maximum Load Applied. Lbs. per sq. in. |
|---|---|---|---|---|---|---|
| 1 | 90.73 | 20 | 0 | 26.2 | 2,600,962 | 28,667* |
| 2 | 90.33 | 36 | 5 | 47.2 | 2,600,962 | 28,794* |
| 3 | 90.78 | 36 | 5 | 47.1 | 2,675,183 | 29,469† |
| 4 | 90.32 | 36 | 5 | 47.2 | 2,726,815 | 30,191† |
| 5 | 89.96 | 36 | 5 | 47.1 | 2,742,950 | 30,490‡ |

*Did not reach failure.
†Failed by bulging of plates in front of pins.
‡Failed by web-plates buckling inward, 12½ ft. from one end.

It will be noted that, accepting Mr. Howard's judgment, these five columns showed an ultimate strength of about 30,500 lbs. per sq. in.; the relatively short length-ratio and the stiff make-up of the columns, assisted by transverse diaphragms, are to be noted in this connection.

Important auxiliary information, however, is given by the compression observations plotted in the diagrams Figs. 1 and 2, herewith. From Fig. 1 it will be seen that the columns departed from strictly proportional compression at a load as low as 20,000 lbs. per sq. in., although up to this point proportionality was well maintained. The departure from a straight line is coincident with the beginning of permanent set. It is to be remembered that these curves refer to the central 20 ft. of length; the gage points being about 8 ft. from the pins, no effect of local action near the ends is included here.

That the action at the ends is very markedly different from the shaft compression will be seen from Fig. 2, where the compression on the total length, including the pin distortion, is compared with the compression of the middle 20 ft. A large departure from the line representing E = 29,500,000 lbs. characterizes the curve of full-length measurements, so that evidently the deformation of the pins and the abnormal compression in the end section of the column (where the stresses are concentrated) form an important part of the total shortening. But the curve, while of flatter slope, does not depart from straight alinement until about the same stress at which the shaft compression shows first set, i. e., about 20,000 lbs. per sq. in.

Counting the column and pins together, the equivalent value of E appears to be about 24,500,000 lbs. per sq. in., and we have added a line to Mr. Howard's diagram to show this value. Also, taking the inelastic shaft compression from the left-hand curve, we have deducted it (after multiplying by 437/240) from the total compression curve, and thus obtained two areas representing separately the yielding in the pin bearing and the yielding in the shaft.

The curves of Fig. 1 and Fig. 2, taken together, show that the pin ends and the column shaft reached their elastic limit about the same time, after which permanent set continued to develop both in the pin-plates and in the shaft, up to failure. In Fig. 1 the curve for Col. 5 is quite the same as those for the other two columns, so that evidently the same kind of action occurred in Col. 2 (which did not reach failure) and Col. 3 (which failed in the pin-plates) as in the body-failure case of Col. 5. But in the latter, we must conclude, the yielding above 22,000 per sq. in. is chargeable to passing the elastic limit of the column as a whole. Therefore the three curves of Fig. 1 demonstrate that all the columns of the series reached their elastic limit at a load not far from 20,000 lbs. per sq. in.

It seems likely that repetitive loading anywhere in the zone of yielding would have produced progressive set, probably with ultimate failure at loads well below the failure load of these tests. However, Mr. Howard gives no records of the effect of load-repetition in his paper, except for a remark referring to a relatively low stage of loading (8,817 lbs. per sq. in.), where he says the load was applied several times, "which exhausted the early but slight permanent sets of the column, if there were any."

The detail compression measurements taken at numerous points, most of them on lengths of 10 ins., exhibit the important general fact that *the deformations were quite consistent*, or we may say systematic (as contrasted with the erratic results obtained in the Illinois series of tests, noted farther on). They also show the behavior of some of the column details, as follows:

*Action of Pin-Plate.*—The (outside) pin-plate showed a relatively large longitudinal movement with respect to the web-plate, but returned on release of load. That is, the movement was not a slip, but was due to elastic yield of the parts connecting the pin-plate to the web. The transfer of load from pin-plate to web occurred mainly near the pin; the far half of the pin-plate showed only small compression, while its motion with respect to the web was large; the compression in the web just beyond the pin-plate was also large.

Permanent set appeared in the pin-plate just ahead of the pin at loads giving a pin-bearing pressure of about 28,000 lbs. per sq. in. From here up to a pin-bearing pressure of 50,000, which was near the maximum load, the permanent set in front of the pin increased very rapidly, on a straight-line curve. In other words, the preliminaries of failure were going on actively in the pin-plates even at loads giving less than 20,000 lbs. per sq. in. in the shaft of the column. The permanent set was mainly confined to the half length of the pin-plate nearest the pin, except when local bulging developed, in which case the whole pin-plate showed deformations and also slipped on the web.

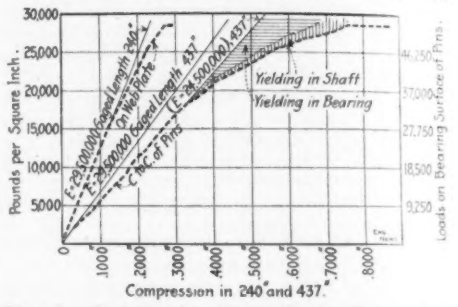


Fig. 2. Comparative Stress-Strain Curves from Compression Test of Steel Column, for Middle Half of Length and for Full Length Including Pins.

(Same column as represented by middle curve of Fig. 1.)

*Action in Shaft of Column.*—In the body of the member the compression was very uniformly distributed over the width of the web-plate, and the angles. The web expanded in width by an amount agreeing well with the accepted ratio of 1:3.55. Over the transverse diaphragms the expansion was slightly less in some cases, but generally no restraining effect of the diaphragm could be noticed.

*Action of Tie-Plates and Lacing.*—The tie-plates connecting the ribs at the ends of the lacing showed a longitudinal compression much less in the middle of their width than at the edges. The edge compression was about the same as the compression of the angles in the same region.

The lacing-bars (single lacing, 2½ × ⅜-in. bars, about 60°) showed generally no compression, except that those close to the tie-plates showed a very slight compression at high loads. Generally the bars acted only as links connecting the two ribs.

The spreading-apart of the ribs was in proportion to this action of the lacing-bars. At the transverse diaphragms, however, there was no spreading.

*Symmetry of Action.*—The deformations visible in the columns after failure were in all cases substantially symmetrical as between the two ribs; nor was there any twisting of the column. Just as interesting perhaps is the fact that there was no primary failure of the lacing. In the case of Col. 5, which failed in the body, the buckling of the web-plate brought about the buckling of one or two lacing bars, but with this exception the lacing did not share in the failure.

SUMMARY.—On the whole, therefore, these tests showed, in spite of the lightness of lacing, an unusual degree of unity of action in the columns, and essential absence of local wrinkling or buckling. Failure of details resulted at the

ends, but this was of such character as to permit the stressing of the body of the column to go on, and the tests proceeded to actual body-failure. The figures for this latter were approximately: *Elastic limit* 20,000 to 22,000 lbs. per sq. in.; *Ultimate strength* 30,000 lbs. per sq. in.

**Column Tests at the University of Illinois.**

A series of experiments and tests was made at the University of Illinois on some compression members of moderate size.* Measurements of local compressions were made at a large number of points on ribs and lacing, to throw light on the uniformity or variation of stress throughout such columns. Auxiliary tests were made on lacing-bars mounted in a testing machine in a way to simulate their attachment in a column. Some deflection tests of the test columns under transverse loading, as beams, were also made, in order to reveal the part played by the lacing in the lateral bending of the column. All the columns tested were relatively short, the length ratio varying from 30 to 66, and for most of the tests only from 37 to 43.

The columns tested were the following:

COL. 1.—A specially-built test column of flimsy make-up, consisting of two ribs 20 ins. deep, 13⅛ ins. back to back, each rib consisting of one 20 × ⅜-in. plate and two angles 2 × 2 × ¼-in. Inner and outer pin-plates bolted to each rib at the ends, seating 5-in. pins. Two sizes of lacing were provided, 1 × ¼-in. and 1¼ × 7/16-in. Lacing and end tie-plates were intended to be tried both riveted and bolted. The rim-plate bolts were ¾-in.; all other rivets and bolts ½-in. Length of column, 20 ft. 7 ins. between pin centers; cross-sectional area of column, 18.76 sq. ins.; length-ratio $l/r$ about 37 (for the full column section in both directions as well as for one rib between lacing rivets).

COLS. 2 TO 5.—Wrought-iron posts of a bridge of C., B. & Q. R. R. being removed. Each column consisted of two 10-in., 30-lb. channels (old pattern) 11½ ins. apart, back to back, with double lacing 2½ × ⅜-in.; ends fitted for 4½-in. pins parallel to plane of lacing; area of section, 17.64 sq. ins.; length, 15 ft. 5½ ins. c. to c. pins; greatest length-ratio, 43.5, for axis perpendicular to lacing.

The preceding columns were tested in the laboratory. Tests were also made on a pair of posts and one top-chord section of a railway

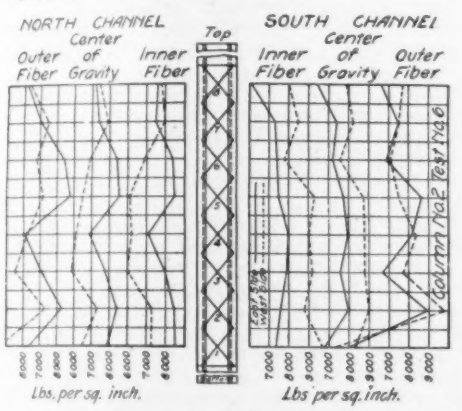


Fig. 3. Diagram of Stresses in Channels of Wrought-Iron Column (Col. 2); Tests of Talbot and Moore.

bridge of the Illinois Central at White Heath, Ill., the bridge being loaded by an engine and two cars for the purpose of the tests. These members had the following characteristics:

BRIDGE POSTS.—The post adjoining the middle post of an 8-panel Pratt truss bridge of 158½-ft. span, depth, 25 ft. c. to c. chords; two 12-in., 20-lb. channels placed 13¼ ins. apart back to back, with 2¼ × ⅝-in. double lacing; upper end riveted, lower end pin; floor-beam riveted to face of inner channel. Area of cross-section, 12.02 sq. ins.; greatest length-ratio, 66.1, for axis parallel to lacing.

UPPER CHORD.—Panel next center. Inverted U-section, consisting of two ribs 14 ins. deep, set 14 ins. back to back, and connected by a top cover plate 21 × 9/16-in. Each rib consisted of a web-plate 14 × 11/16-in. and two angles 3½ × 3½ × 7/16-in. Bottom face laced with 2¾ × ⅝-in. lacing. Pin-bearings in ends for diagonals; adjoining chords and posts attached by splice and gusset plates. Area of section, 48.67 sq. ins.; length c. to c., 19 ft. 10 ins.; greatest length-ratio, 40.7, for horizontal axis.

The special test column, Col. 1, was loaded a large number of times to a point well within its elastic limit and extensometers were applied successively at different lacing spaces. At each section they were applied to three points of the width of each flange of each channel, 12 points in all. The corresponding stresses were computed from the measured compressions by using a uniform modulus of elasticity (28,000,000 lbs. per sq. in.).

*Bulletin 44 of the University of Illinois Experiment Station, by Profs. A. N. Talbot and H. F. Moore.

TABLE II.—FAILURE TESTS OF SEVEN STEEL AND WROUGHT-IRON COLUMNS.
(By A. N. Talbot and H. F. Moore, University of Illinois.)

| Col. No. | Section area, sq. ins. | Length, ft. | Length, ins. | Max. $l/r$ | *Failure Load— lbs./sq. in. | *Failure Load— †Per cent. of strength of short pieces. | Load at first sign of yielding, lbs./sq. in. | Kind of Failure. |
|---|---|---|---|---|---|---|---|---|
| ‡1 | 18.76 | 21 | 0 | 37.8 | 23,450 | .... | 12,000 | Sudden buckling of flange between adjacent lacing bars. |
| 2 | 17.64 | 15 | 10 | 43.5 | 26,400 | 71.5% | 18,000 | End failed. Cut off injured end and retested as Col. 2*a*. |
| 3 | 17.64 | 15 | 10 | 43.5 | 27,200 | 73.8% | 15,000 | End failed. |
| 4 | 17.64 | 15 | 10 | 43.5 | 25,700 | 69.6% | 14,500 | End failed. Cut off injured end and retested as Col. 4*a*. |
| 5 | 17.64 | 15 | 10 | 43.5 | 27,900 | 75.8% | 15,000 | Bowed at middle in plane at right angle to lacing. |
| 2*a* | 17.64 | 14 | 7 | 40.1 | 26,900 | 73.0% | .... | Buckled near bottom in plane parallel to lacing. |
| 4*a* | 17.64 | 14 | 7 | 40.1 | 26,900 | 73.0% | .... | Bowed at middle in plane at right angle to lacing. |

*The loading was central in all tests except 2*a*, where the loading was "oblique," with eccentricity of 1-in. at each end, in opposite directions, in plane of lacing.
The total load at failure, in the seven tests here listed, ranged from 440,000 to 492,000 lbs.
†Computed from test figure of 36,800 lbs. per sq. in. for short piece of wrought-iron member.
‡Col. 1 was steel, all others wrought-iron.

The tables, as well as the plotted diagrams of the readings, show a very remarkable degree of variability of the compressive stress along the length of the column. The differences of stress between the two channels were of similar magnitude and irregular character, but the differences between inner and outer fiber of a channel flange and between the two flanges of a channel were less considerable. Variations of 50% of the average column stress occurred rather often. The results show clearly that the column was far from a condition of reasonably uniform stress-distribution. The variations on the whole seem to have been quite erratic, i. e., not traceable to any definite cause.

The stresses in the bars of the lacing of Col. 1 were also measured, partly while making the measurements of main stresses and partly in separate tests. They proved to be rather considerable in amount and quite variable as between different bars (a result very different from that disclosed in Howard and Buchanan's tests). Talbot and Moore compute the maximum lacing stresses in terms of the column load for the various tests, and show that the equivalent transverse shear ranged from 1% to 3% of the column load.

Precisely similar tests were made with the wrought-iron bridge columns, Cols. 2 to 5. These were stocky compared with Col. 1, but they showed equally large variations of main-section stress. One of the plots of test results, showing rather more erratic character than the average, is reproduced herewith as Fig. 3.

An interesting part of the work of Talbot and Moore is the ultimate test to failure of these columns. Cols. 1 to 5 were tested to failure after the stress-measurements. Col. 1 experienced an accidental failure early in its history, due to buckling of the light lacing under oblique load.* It was fitted with the heavier lacing and tested for stress distribution first with the lighter lacing, then with the heavier lacing and finally was loaded to failure. This later test is included with the failure tests of the wrought-iron columns in the subjoined Table II.

In the failure test of Col. 1 the shortening was progressively measured by instruments attached near the middle of the column. The stress-strain curves plotted from these measurements are given in Fig. 4. Failure took place in lacing-

*Oblique load means load eccentric to one side of center at top and to other side of center at bottom, so that one channel carries most of the load at one end, the other channel most of the load at the other end, and the transfer of load occurs through the lacing. A number of the tests were actually made under such oblique loading, but as concerns compressive deformation they did not differ materially from the tests under central or one-sided eccentric load. The first failure of Col. 1 occurred under preliminary loading at a load of only 8,000 lbs. per sq. in. of main section.

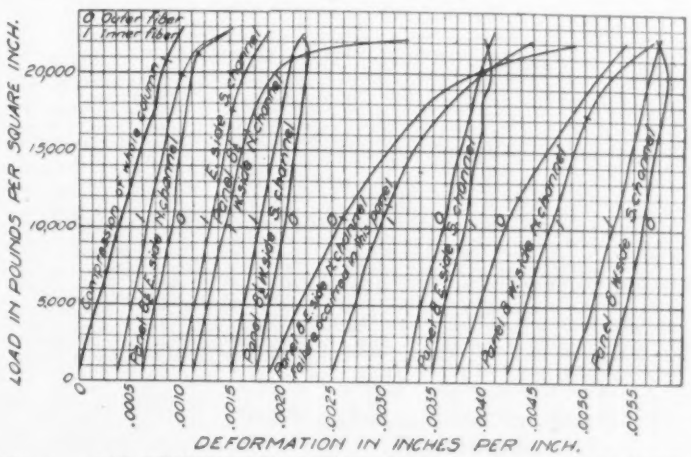


FIG. 4. LOAD-DEFORMATION CURVES FOR FAILURE TEST OF STEEL COLUMN (COL. 1.); TESTS OF TALBOT AND MOORE.
(Lacing of 1¼ × 7/16-in. bars, riveted.)

space S by local buckling of the north channel; this is one of the sections represented in Fig. 4. From these curves the authors apparently derive the tabular figure (see Table II.) of 12,000 lbs. per sq. in. for average stress at first sign of yielding, but it may well be questioned whether the curves shown justify such a conclusion. For the purposes of the engineer interested in fixing permissible stresses we will not go far wrong if we place the *beginning of yield* at 20,000 to 21,000 lbs. per sq. in. For the wrought-iron columns (2 to 5) no such curves are shown and it is not possible to verify the authors' figure for "load at first sign of yielding."

The tests of posts and top chord of the White Heath bridge covered a live-load stress of about 5,000 lbs. per sq. in. as a maximum load. The dead-load stress is not stated and of course could not be measured, so that the total range of stress is not known. The measured amounts of shortening in different parts of the length of the members showed about the same degree of variation as in the laboratory tests, but the results were indicative of more twisting and bending action (due no doubt to the influence of attachment of other members, bending transferred from floorbeam to post, and similar causes). The two posts tested showed maximum excesses of local stress over average stress ranging around 60%, while in the chord the largest excess measured was 20%.

TESTS OF LACING-BARS.—Various sizes of lattice-bars and angles, and small channels suitable for use as lattice members, were tested in compression in the laboratory testing-machine. These showed very marked amounts of bending (due to the slightly eccentric method of loading, simulating the attachment of a lacing-bar in an actual column). The values of ultimate strength found were surprisingly low, the highest being only 22,000 lbs. The bars tested covered a considerable range of length-ratio, from 70 to 277, and the plotted values give an excellent straight-line average, having the value

$$p = 21{,}400 - 45\ l/r.$$

CROSS-BENDING TESTS.—Tests of Cols. 1 and 4 in cross bending, the deflections being

measured, showed that the deflection curves were of similar form to that computed by the ordinary flexure formulas (except for bolted lacing, which gave a deflection curve peaked sharply in the middle). The maximum deflection, however, was in all cases greater than the computed, due to the influence of web shear. In Col. 1, with very weak lacing, the excess was as much as 150%, while in the case of Col. 4, which had fairly substantial lacing, the excess was only about 25%.

SUMMARY.—The authors recapitulate their work at the close of the bulletin, and from this place we extract some of their principal conclusions as follows:

Considerable local flexural action exists in the channel members of the columns, especially in the flimsier column.

The condition of flexure varies markedly throughout the length of the channel member, in some cases the maximum compression in one cross-section being at the extreme fiber on one side of the channel, and in a near-by section the other side of the channel showing the excess of stress. There were also indications of sudden changes in the relative amount of stress carried by the two channels at near-by sections, indicating general flexure of the column. The measurements made indicate in a number of cases stresses in the extreme fiber from 40% to 50% in excess of the average stress, and in some cases even higher.

The measurements indicate a stress in the lattice bars which would be produced by a transverse shear of amount from 1% to 3% of the load in the column. The stress referred to is the average stress over the section of the lattice bar. It seems futile to attempt to determine the stresses which may be expected in column lacing for central loading by analysis based on theoretical considerations or on data now available.

Tests of individual lattice-bars for load-carrying capacity under conditions which resemble those of service show that the usual form of bar is a very inefficient compression member when loaded eccentrically through a riveted connection. The ultimate strength was in no case as much as one-half of the yield point of the material. The formula

$$\frac{P}{A} = 21{,}400 - 45\,\frac{l}{r}$$

represents fairly well the ultimate strength of the flat lattice-bars tested, based on material having a yield-point of 40,000 lbs. per sq. in.

It seems evident that the component members of a built-up column do not act together in such a way as to give entire integrity of cross-section in resisting bending.

No relation has been found between the stresses actually observed and the stresses computed by column formulas. The stresses do not increase toward the middle of the length of the column, as may be expected from the Rankine form of analysis, but are quite irregular in their location and distribution. Much of the excess of extreme-fiber stress over average stress is evidently attributable to local crookedness of piece, eccentricity of bearing of lattice-bar connection, lack of rigidity of lacing and other irregularities that are due to the condition of the material and its fabrication, and what may be considered to be inherent variations and defects in the constructed compression piece. The lateral flexure of the column as a whole is very slight, and slenderness ratio cannot be said to be the governing consideration. Undoubtedly, the chances for variations from the ideal column will become greater as the column length becomes greater, and these variations may have a more marked effect upon its strength. It is evident that the form of section is important. Stocky and stiff component members are less liable to receive kinks, bends, and distortions during and after fabrication and will resist the effect of such imperfections with less resulting stress than will flimsy pieces.

## The Passage of the Appalachian Forest Reserve Bill.

After a long series of discouraging opposition and postponement a bill which has been popularly known as the Weeks Appalachian Forest Reserve bill passed the last session of Congress and was approved by President Taft on March 1. The Act does not directly create forest reservations in the Appalachian region. In fact, it is so general in character that under its provisions action might be taken in any part of the United States. A good general idea of the nature and scope of the Act may be gained from its title: "An Act to enable any State to cooperate with any other State or States, or with the United States, for the protection of the watersheds of navigable streams, and to appoint a commission for the acquisition of lands for the purpose of conserving the navigability of navigable rivers."

The first section of the Act enables any state of the Union to enter into an agreement with any other state or states "for the purpose of conserving the forests and the water-supply of such states."

The next section puts in the hands of the Secretary of Agriculture the sum of $200,000 for the purpose of cooperating "with any state or group of states, when requested to do so, in the protection from fire of the forested watersheds of navigable streams." This authorization limits the amount of federal money expended in any state in any given year to the amount appropriated by that state for the same purpose during the same year.

The most significant sections of the Act are those which provide for the establishment of forest reserves. The first element in this provision is an appropriation of $2,000,000 a year for five years ending with June 30, 1915, "for use in the examination, survey, and acquirement of lands located in the headwaters of navigable streams or those which are being or which may be developed for navigable purposes." The expenditure of money under this provision of the Act is conditioned (1) upon investigation by the Secretary of Agriculture, (2) examination and approval by the Geological Survey, (3) recommendation for the purchase of lands and fixing of price by the National Forest Reservation Commission, (4) and finally actual purchase by the Secretary of Agriculture, with approval as to payments and land title by the Attorney-General of the United States.

The National Forest Reservation Commission created by the Act is to consist of seven members, including the Secretaries of War, Interior, and Agriculture; two members of the Senate, chosen by the President of the Senate; and two members of the House, chosen by the Speaker. This Commission is to report annually to Congress about Dec. 1 on the operations of the preceding fiscal year. The specific provisions of the Act as regards the Secretary of Agriculture and the Geological Survey, together with provisions for reservation of minerals and timber to the original owners of purchased lands, and also provisions for homestead entries on small tracts suitable to agricultural purposes may be quoted as follows:

Sec. 6. That the Secretary of Agriculture is hereby authorized and directed to examine, locate, and recommend for purchase such lands as in his judgment may be necessary to the regulation of the flow of navigable streams, and to report to the National Forest Reservation Commission the results of such examinations: Provided, That before any lands are purchased by the National Forest Reservation Commission said lands shall be examined by the Geological Survey and a report made to the Secretary of Agriculture, showing that the control of such lands will promote or protect the navigation of streams on whose watersheds they lie.

Sec. 7. That the Secretary of Agriculture is hereby authorized to purchase, in the name of the United States, such lands as have been approved for purchase by the National Forest Reservation Commission at the price or prices fixed by said commission: Provided, That no deed or other instrument of conveyance shall be accepted or approved by the Secretary of Agriculture under this Act until the legislature of the State in which the land lies shall have consented to the acquisition of such land by the United States for the purpose of preserving the navigability of navigable streams.

Sec. 8. That the Secretary of Agriculture may do all things necessary to secure the safe title in the United States to the lands to be acquired under this Act, but no payment shall be made for any such lands until the title shall be satisfactory to the Attorney-General and shall be vested in the United States.

Sec. 9. That such acquisition may in any case be conditioned upon the exception and reservation to the owner from whom title passes to the United States of the minerals and of the merchantable timber, or either or any part of them, within or upon such lands at the date of the conveyance, but in every case such exception and reservation and the time within which such timber shall be removed and the rules and regulations under which the cutting and removal of such timber and the mining and removal of such minerals shall be done shall be expressed in the written instrument of conveyance, and thereafter the mining, cutting, and removal of the minerals and timber so excepted and reserved shall be done only under and in obedience to the rules and regulations so expressed.

Sec. 10. That inasmuch as small areas of land chiefly valuable for agriculture may of necessity or by inadvertence be included in tracts acquired under this Act, the Secretary of Agriculture may, in his discretion, and he is hereby authorized, upon application or otherwise, to examine and ascertain the location and extent of such areas as in his opinion may be occupied for agricultural purposes without injury to the forests or to stream flow and which are not needed for public purposes, and may list and describe the same by metes and bounds, or otherwise, and offer them for sale as homesteads at their true value, to be fixed by him, to actual settlers, in tracts not exceeding eighty acres in area, under such joint rules and regulations as the Secretary of Agriculture and the Secretary of the Interior may prescribe; and in case of such sale the jurisdiction over the lands sold shall, ipso facto, revert to the State in which the lands sold lie. And no right, title, interest, or claim in or to any lands acquired under this Act, or the waters thereon, or the products, resources, or use thereof after such lands shall have been so acquired, shall be initiated or perfected, except as in this section provided.

Lands purchased under the provision of the Act are to be administered as "national forest lands" under Sec. 24 of the Congressional Act, approved March 3, 1891, and various supplemental Acts. The Secretary of Agriculture is authorized to divide any lands purchased "into such specific national forests" as may to him appear best for administrative purposes.

The Act provides that 5% of any money received during the fiscal year from each of the national forests thus created shall be paid into the Treasury of the state in which such forest is located, "to be expended as the state legislature may prescribe for the benefit of the public schools and public roads of the county or counties in which such national forest is situated." No county, however, is to receive an amount in excess of 40% of its total income from all other sources.

Finally the Act appropriates $25,000 per year for the expenses of the National Forest Reservation Commission, the money to be immediately available.

## Carbon Tetrachloride as a Fire Extinguisher.

In the January issue of the Quarterly of the National Fire Protection Association, Mr. J. A. Robinson discusses the use of carbon tetrachloride as a fire extinguisher and as a substitute for naptha in industrial processes. From this discussion it is seen that this compound has the properties of non-inflammability and solveney which have been desired for manufacturing processes by fire protection engineers and insurance underwriters for a long time. These properties of carbon tetrachloride have been known in the past, but the high cost of the compound has greatly limited its use. There has also been a lack of information concerning its commercial adaptability.

The development of electrolytic cells for the production of chlorine and caustic soda, with the resultant cheapening of chlorine gas, has opened a way for the cheaper manufacture of this compound. Chlorine gas is passed over heated carbon bisulphide and the products are condensed. This results in a mixture of carbon tetrachloride and sulphur dichloride. By injecting caustic soda or potash into this mixture now, the sulphur dichloride is decomposed and dissolved. The carbon tetrachloride separates and falls to the bottom, from which it may be recovered for purification by distilling. At present the carbon tetrachloride is sold in 100-gal. drums and in smaller containers. It weighs about 13.5 lbs. per gal. and sells for about 10 cts. per lb. in drums. There is a gradual increase for smaller lots, 5 gals. being quoted at about 13 cts. per gal.

This compound is a clear, colorless volatile liquid having a specific gravity of 1.604 and a boiling point of 78° C. It is non-inflammable and non-explosive, and its vapors smother fire. Fire extinguishers are already on the market using carbon tetrachloride, and they seem to have been very extensively adopted in the cars of the Interborough Rapid Transit Co. in New York City. The vapor has been used, elsewhere, to smother the arc which has followed short circuits. The use of this compound in such extinguishers seems to be specially useful for electrical work, where it is known that water is often worse than nothing. Sand has been used in the absence of something better, but even this is hardly satisfactory. What has been desired for such work is a compound, which would be insulating, non-inflammable, and non-corrosive; this seems to have been found in carbon tetrachloride.

It is satisfactory for extracting oils from seeds, fats, wool, cotton, etc., and in a shorter time than will naphtha. In some cases it has been found desirable to use a certain percentage of naphtha with the carbon tetrachloride, and the percentage of naphtha which can be added and still leave the mixture free from hazard is as follows: A 55° naphtha to be reasonably safe should contain 30% carbon tetrachloride; a 63° naphtha, at ordinary room temperatures, should have at least 45% of tetrachloride; a 70° naphtha, or a motor gasoline, should have 50% to be free from explosion hazard and 60% to be safe from fire hazard; a 76° naphtha, to be safe from explosion, should contain 60% carbon tetrachloride and 70% for safety against fire hazard. These percentages are limiting ones and good practice demands an additional 5% of tetrachloride to provide a factor of safety. These figures were obtained from tests by Mr. E. A. Barrier, M. Am. Chem. Soc., whose results were published by the American Chemical Society in its "Journal of Industrial and Engineering Chemistry," Vol. II., No. 1.

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Long before the national conservation movement began, investigation of the equalization of stream flow for the benefit of water power and for the prevention of floods had been started in New York State. During the period 1902-1905 several commissions were created in New York State, and in 1906 the work of all of them was merged in the State Water Supply Commission, which had been established in 1905. Proceeding under an act of 1904, designed to make possible the regulation of any stream in the state, under stipulated conditions, a large amount of work has been done on a project for storing the waters of the Genesee, and thus equalizing the water power available at Rochester, at the same time guarding against and reducing flood damages and improving the general sanitary condition of the river below the sewer outfalls of that city.

Elsewhere in this issue the Genesee River dam and storage project is described in some detail. As will be seen from the article, plans and estimates have been prepared and the requirements regarding distribution of cost have been complied with, all to such an extent that the project may be said to be ready for the letting of contracts. In accordance with the statute, a hearing was ordered for Feb. 2, 1911. After the hearing, as we understand the situation, it only remains for the legislature to enact further statutes giving specific authorization for carrying out the project. Such an act, we understand, was presented in the last legislature, but met defeat because it did not meet the ideas of some of those who were to be called upon to pay for the benefits which would result to the water-power interests. Meanwhile, the project as a whole has been worked out in more detail and perhaps perfected in various important points.

It is to be hoped that the Genesee project will now go forward to actual construction and that in adjusting the various conflicting interests due regard will be had to the rights of the people of the state, while at the same time not imposing any unwarranted burdens upon any of the parties who are to be directly benefited through the use of water power or the prevention of flood damages. It goes without saying that an adjustment of these various conflicting interests is a troublesome question, especially as it involves matters which thus far have been given but little consideration in this country.

Until very recent years water-power interests have reaped whatever benefits might arise from federal or state stream improvements without paying a cent towards the original cost. This has been notably true in the case of many federal improvements to navigation, and also, if we are rightly informed, in connection with water powers which have been developed incidental to the storage of water for use by the New York State canals. The time for this sort of thing has passed. We trust the water-power interests at Rochester and elsewhere in the state are now ready to admit this and to cooperate in the Genesee project. The carrying out of this project would be of great benefit not only in and of itself, but as an object lesson which would make easier the success of similar projects elsewhere.

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By an act of the recently adjourned Congress, signed by the President on Feb. 27, 1911, the increase in the Engineer Corps of the United States Army, is carried out practically as intended by the act of 1910, which failed of passage. As many of our readers will remember, this latter act was the subject of much comment and controversy in our columns, particularly on account of its original promise of bettering the status of the civilian engineers in the employ of the Corps. A reading of the law, printed on another page of this issue, will show how imperfectly this promise has been fulfilled.

The law calls for 60 more engineer officers, to be added gradually during the next five years —a very necessary increase to a much overworked body of men—but the provisions are such that it is only remotely possible that any civilian will ever receive a commission and such civilians as are so honored, must necessarily be from a class of men new to the work they have to perform and unequal to immediate positions of responsibility. There is no honor or prospect of advancement in view for the older and experienced members of the civilian branch of the service, except the possibility of assignment, without rank or additional pay, to such responsible positions, on boards or in charge of divisions, as the Chief of Engineers is, for the moment, unable to fill with members of the commissioned corps.

It is perhaps unnecessary for us to add our regret at the passing of this opportunity to provide some suitable recognition of a corps of men to whom, equally with their superiors, the engineer officers, is due the great prestige of the United States Engineer Corps.

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A few days before the end of the recent session of Congress, the administration authorities finally agreed to withdraw the rider to the Post-Office appropriation bill increasing the second-class postal rate on those magazines carrying advertising pages and substituted therefor a clause providing for a commission to investigate the question and to report upon it before the next regular session of Congress. The main features of the act, which was passed by Congress and signed by the President, are as follows:

Provided, That the President shall appoint three competent and impartial persons, one of whom may be a judicial or other officer of the United States and the other two of whom shall hold no office, and no one of whom shall be connected with the Post Office Department or have any interest in any business directly or indirectly affected by the publishing of magazines or newspapers using the mails of the United States, to examine the reports the Post Office Department and any of its officers, agents, or employees, and the existing evidence taken in respect to the cost to the Government of the transportation and handling of all classes of second-class matter which may be submitted to them, and such evidence as may be presented to them by persons having an interest in the rates to be fixed for second-class mail matter, to make a finding of what the cost of transporting and handling different classes of such second-class mail matter is to the Government and what in their judgment should be the rate for the different classes of second-class postal matter, in order to meet and reimburse the Government for the expense to which it is put in the transportation and handling of such matter, and on or before Dec. 1, 1911, to make report of their proceedings and findings to the President for transmission to Congress.

This procedure will appeal to all fair-minded persons as a much wiser plan than the previous arbitrary levy of an increased rate on a certain class of mail at the instance of the post-office authorities alone. A thorough inquiry, under the direction of so experienced an investigator as Mr. Justice Hughes, of the United States Supreme Court, who is to be the official member of the commission, will certainly remove many of the misconceptions as to the basis of railway mail rates and perhaps throw some light on the other extravagances of the Department, which are claimed to bear more than a fair share of responsibility for the annual deficit.

In passing it is pertinent to note that the post-office appropriation bill this year carries about 258 million dollars, distributed roughly as follows: Rural free delivery, 43 millions; railway transportation, 50 millions; railway mail service, aside from moneys to railways proper, 25 millions; salaries of postmasters, 29 millions; salaries of all other clerks, assistants and carriers, 71 millions; all other expenses, 41 millions. Here are the heads of the offices, one person to each office, and in nearly all cases political appointees, drawing salaries aggregating 40% of the salaries of all their subordinates; railways being paid one-half as much as is paid to all employees in the fixed offices; a rural free delivery costing at the delivery end alone 17% of the entire cost of the service; these are all worth looking into. The magazine publishers are willing to make up their just proportion of the deficit which annually burdens the department, but they claim at the same time that that proportion is not fairly arrived at by assessing to them the actual ledger difference between what they pay into the department and what the department thinks it must pay out for the transportation and delivery of second-class mail. A fair distribution of the burden of the deficit must consider all, not one, of the items that go to make it up.

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It will be a source of gratification to many of our readers to know that the so-called Weeks' Appalachian Forest Reserve bill has at last become a law. The features of the bill are given in detail elsewhere in this issue. The results that will flow from the passage of the bill, under the Secretary of Agriculture, the Geological Survey, and the National Forest Reservation Commission, as well as developments through co-operation by various states, will be watched with interest. Particularly interesting it will be to note the correlation between forestry, water-supply, in the broad meaning of the term, and navigable streams which results from the execution of the various provisions of the Act.

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It appears that Congress has again adjourned without passing any of the several acts introduced within the past year or so to create a bureau or department of health. A bill did get through the House changing the awkward title of the Public Health and Marine-Hospital Service to the simple designation Public Health Service and giving the Service power to investigate diseases of man and their spread, including also sanitation and sewage and the pollution of navigable waters. but the bill did not pass the Senate. It therefore devolves upon a future session of Congress to place the United States in the same class with other civilized nations of the world in the matter of national health-protective service. How far short this country is in this and some allied matters may be illustrated by some of the tables of vital statistics published in the annual reports of the Registrar General for England. These reports give comparative vital statistics for numerous countries of the world but omit the United States. This omission is due to the fact that our country as a whole has not sufficiently reliable vital statistics to make it worth while to tabulate them for comparative purposes. We hasten to add that for this sad

lack the United States is not primarily responsible, since under our system of government the states and not the nation are responsible for the registration of vital statistics. The creation of a bureau or department of health would not in itself remedy this matter. Possibly it might stimulate action on the part of the states, but so far as that is concerned it is to be noted that the Vital Statistics Division of the Bureau of the Census is and for a few years has been using all proper means to increase the registration area by bringing additional states into line through proper legal and financial provisions for the registration of vital statistics.

In our issue of July 9, 1909, we published an interesting article telling how the city councils of Staunton, Va., had entrusted the general management of nearly all city affairs to a business manager in the same general way as would the directors of a private corporation the affairs under their direction. Elsewhere in this issue, in an article on the city-commission plan propaganda in New York and New Jersey, we outline the scheme which has been proposed by the Board of Trade of Lockport, N. Y., which will enable the many cities of the third class in New York State to entrust their affairs to a business manager. The proposal also entails the adoption of most of the features of the commission plan of city government—only the five-membered commission would entrust all executive and administrative work to a single manager appointed by the commission and under its general control. The manager, however, would appoint all executive officers who are under his direction. The plan has much to commend it, at least as an experiment or a continuation of the Staunton experiment, worthy of trial on a somewhat extended scale. This plan, as well as the widespread agitation throughout the country for the adoption of the commission plan, is certainly a most healthy sign that at last the people of our cities are awaking to the need of fundamental changes in the administration of municipal affairs. It is particularly interesting to note that so large a city as Buffalo, N. Y., is working heart, head and hand for the commission plan, and that the Chamber of Commerce has endorsed the commission charter now before the legislature (outlined elsewhere in this issue) by a vote of 318 to 31.

## Column Stresses in the Light of Tests.

When the results of the Panhandle tests of full-size compression members of bridges were published by Mr. C. P. Buchanan (in our issue of Dec. 26, 1907, pp. 685-695), we pointed out editorially that they showed column strength to be markedly lower than generally assumed, and that in view of this fact column stresses ought to be reduced. There was much dissent from this conclusion, however. It was claimed that the columns described by Mr. Buchanan were of bad design, hence failed at unduly low loads; but no proof was offered to this effect. In the three years since then, nothing has come out that would tend to uphold high estimates of column strength. On the other hand, the new tests of very heavy columns for the Steubenville Bridge of the Pennsylvania Lines, made by Mr. Buchanan in conjunction with Mr. J. E. Howard, confirm our conclusion of three years ago. An excellent presentation of these tests in the "Proceedings of the American Society of Civil Engineers" is abstracted elsewhere in the present issue.

The simple table of test results is so clear that he who runs may read. Five well-built columns, each of 90 sq. ins. section, *the largest compression members yet tested to failure*, reached an ultimate strength barely above 30,000 lbs. per sq. in. Also, they gave indications of a departure from thoroughly elastic behavior at loads of 20,000 to 22,000 lbs. per sq. in. And the fact is that no deficiencies of details contributed to making these figures so low.

We say *well-built* columns, in full recognition of the fact that the lacing employed was of very weak section in proportion to the main members, judging by practice in much smaller columns. The 2½ × ⅝-in. bars are unquestionably very small for a main section of 90 sq. ins. By chance, we see that exactly the same size of bar was used in columns *less than one-fifth as large*, in the tests of Talbot and Moore which we also summarize in this issue; and to make the comparison still worse, the small column has double lacing whereas the large column has only single lacing. It is true that the lacing of the Steubenville columns had a cross-shear section amounting to about 2% of the column section, and percentage in this neighborhood have been recommended in the past, besides finding a certain degree of approval in the Talbot & Moore tests. But it is not on this ground that we speak of the columns as well-built, nor do we mean to assert that the lacing was as strong as good design should provide. The fact is, however, that to all appearances the lacing was not involved in the failure phenomena, i. e., did not contribute to lowering the strength of the columns, so far as can be observed; and this fact warrants us in disregarding the lacing in the particular case of these tests.

As regards the other constructive details of the columns, the high concentration of stresses in the end sections near the pins is bound to claim attention. The careful measurements of deformations near the pins, made with Mr. Howard's new strain-gage, reveal with striking clearness a state of affairs which was hitherto vaguely known to exist. Generalizing rather broadly from the figures which these measurements furnish, we may say that a considerable volume of metal near the pins is stressed about one and one-half times as severely as the body of the column; and the conditions prevailing in the riveted pin-plate attachment make it seem unlikely that the stresses would be much relieved by thicker piling of pin-plates. But even though the end details could be improved, and their stresses brought down into closer agreement with the body stresses of the column, we must assume that the strength of the column would not be increased, in view of Mr. Howard's conclusion that the two columns which failed by pin-plate bulging had at that time nearly reached their ultimate body load, and that the body failure of Col. 5 was fairly representative for the entire group.

There is room for interested speculation on the question whether the transverse diaphragms exercised any influence on the strength displayed by the columns. That they were in action, carrying some stress, is shown by the measurements of spread between ribs, taken at the diaphragms and at other points, which prove that the diaphragms opposed the spreading observed at other points. It is also worth note that Col. 5 failed by the web-plates dishing between diaphragms, and that the diaphragms probably made the web stronger against such dishing action, by shortening the unsupported length of plate in one direction. The most important question, however, is whether the diaphragms cooperated with the lacing and therefore reduced the tax on the lacing; and, if so, to what extent this action took place. The question is not susceptible of direct answer. But there is the fact that the measurable lacing stresses in the large columns were extremely small, and contained no large variations, while on the other hand one of the small double-laced columns tested by Talbot and Moore showed these results:

TOTAL LACING-BAR STRESSES IN A WROUGHT-IRON COLUMN; LOAD ON COLUMN, 10,000 LBS. PER SQ. IN. (176,400 LBS. TOTAL).

(Stresses in pounds; c = compression; t = tension.)

| Lacing interval. | Front side— Under bar. | Front side— Over bar. | Back side— Under bar. | Back side— Over bar. |
|---|---|---|---|---|
| 1 ..... | 700 c | 700 c | 1,300 c | 100 c |
| 2 ..... | 100 c | 100 t | 200 t | 200 t |
| 3 ..... | 3,000 t | 0 | 1,000 t | 0 |
| 4 ..... | 100 c | 100 c | 800 c | 200 c |
| 5 ..... | 3,000 t | 0 | 800 c | 300 c |
| 6 ..... | 200 t | 300 c | 0 | 300 c |
| 7 ..... | 3,700 t | 0 | 200 t | 200 c |
| 8 ..... | 0 | 800 c | 800 c | 300 c |

The remarkable variations, if they afford no other conclusion, at least lead to the presumption that transverse diaphragms might be of value in tending to equalize the variations of lacing-stress. Should they have such effect, they would doubtless promote integral action of the column throughout a higher load-range than could otherwise be attained, and in this way they would increase the strength of the column.

Consideration of the various accessory features of the Steubenville column tests, however, only serves to throw into stronger relief the figures of ultimate strength. We repeat that these well-made columns failed at a load of 30,500 lbs. per sq. in. This is to be compared with tensile failure values in large-size tests of 50,000 to 60,000 lbs. per sq. in. net section and represents 50% to 60% of these values. Further, the columns showed departure from elastic action in the neighborhood of 20,000 lbs. per sq. in. Tension test specimens of the metal gave results (represented by a full set of stress-strain diagrams in the paper already noted, but not reproduced in our article), which average as follows:

| | Plates. | Angles. | Average for Col. section (68.7% plates, 31.3% angles) |
|---|---|---|---|
| El. limit ..... | 31570 | 33990 | 32,300 |
| Yield-point..... | 34940 | 35910 | 35,250 |

The elastic limit of the columns in compression therefore represents about 60% of the tensile elastic limit of the material.

To put these figures in words: The compressive *strength of these steel columns, as regards both elastic failure and ultimate failure did not exceed 60% of the tensile value of the metal.*

It seems to us that the direct result of this relation, if confirmed and recognized as a general relation, must be the limitation of compressive unit-stresses to about 60% of tensile unit-stresses. A design whose tension members are proportioned for stresses of 15,000 lbs. per sq. in. should have its compression members proportioned for 9,000; if 18,000 in tension, then 11,000 in compression; and similarly for other values.

Such is not the practice to-day, needless to remark. In many quarters the current unit-stresses are the same in tension and compression, with a reduction for column-length only. Some, however, while using a column reduction formula based on the tensile unit value, limit its application by disregarding all derived values above some 90% of the tensile unit-value. For all except very short columns, both methods give identical results. Taking the difference between net and gross section into account, the average column section shows but little excess over a tension section for the same load. To bring this practice into conformity with the results of the present tests, rather profound changes are needed.

We have referred more particularly to the Buchanan & Howard tests, to the exclusion of Talbot and Moore's tests at the University of Illinois, for the reason that the columns concerned in the former tests are modern, of very large size and of careful design, and belong directly to practice. In the Illinois tests, there was one experimental column of quite abnormal type, and five wrought-iron columns which not only were built in an earlier generation but also have been exposed to the vicissitudes of bridge-removal, multiple re-handling, etc. The effects of these experiences are possibly reflected in the erratic list of lacing-bar stresses given above, and in any case would be likely to produce a low column-strength. For this and other reasons the tests of these old iron columns may not be very convincing when opposed to modern designing practice, whereas the Steubenville columns are free from such objection.

It is, however, of some interest that the Illinois tests are in fairly good agreement with the others, in the matter of the ratios we have discussed. Figures given in the bulletin reporting the Illinois tests yield the following tabulation:

| Column Tests. | Tension specimen tests. | Ratio Col. / Tens. |
|---|---|---|
| El. limit ....15,625 (av. of 4) | 30,700 (av. of 3) | 51% |
| Ult. strength..26,830 (av. of 6) | 46,800 (av. of 3) | 57.5% |

These figures in view of the uncertainties surrounding all test work, must be regarded as substantially identical with the ratios found for the large columns. On no account would they support any value of column strength greater than the figure of 60% above employed.

Nor do the circumstances of the tests give any reason for believing that these old columns *while in the bridge* could have withstood a materially

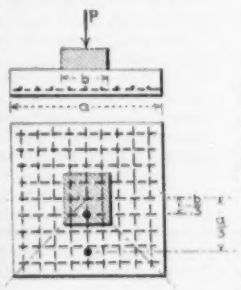
greater load than that found in the testing-machine; or that they could during their service have endured without progressive injury an oft-repeated load much greater than the 15,600 lbs. per sq. in. found in the test. It is fair to conclude that if the posts and chords of the bridge from which these columns were taken were proportioned for stresses of 16,000 lbs. per sq. in., they were, under full load, exposed to those progressive effects known to result from repeated loading beyond the elastic limit; that their ultimate factor of safety was not greater than 1.7; that if the tension members in the same bridge were designed for the same maximum stresses, they possessed a factor of safety of about 2.8; and that on the other hand, the tension members might have been proportioned for stresses of 27,000 to 28,000 lbs. per sq. in., with the same safety as obtained in the columns.

We interpret these tests as throwing new light on the subject of column design. Establishing a prima facie case against the standards of column stress now prevailing, they will require full disproof on the basis of thorough, conscientious tests covering a wide range, before present-day stresses can be justified.

## LETTERS TO THE EDITOR.

### What is the Bending Moment in a Square Reinforced Footing Slab?

Sir: Allow me to submit a problem for discussion in your columns which should be of considerable practical importance to a good many of your readers, on account of the frequency of its occurrence and the cost involved. The problem is to determine the maximum bending moment in a square reinforced-concrete foundation slab loaded at the center and reinforced equally in two directions.




I know from my limited acquaintance that some practitioners, considering such a footing slab the reciprocal of a slab supported at two opposite edges, figure $M = \frac{1}{2} P \times \frac{1}{4} (a - b) = \frac{1}{8} P (a - b)$. Others, considering it the reciprocal of a square slab supported at its four edges, figure $M = \frac{1}{4} P \times \frac{1}{4} (a - b) = \frac{1}{16} P (a - b)$. Still others, considering it a cantilever in four directions figure $M = \frac{1}{4} P \times \frac{1}{6} (a - b) = \frac{1}{12} P (a - b)$. The meaning of the letters is indicated in the sketch herewith, which shows also the supposed division in the last-mentioned case.

The literature of the subject is meager and evasive, and disagrees in assumptions and results. A rigid mathematical analysis of the case is difficult, even on the assumption that the ground pressure is uniform (which it is not, on account of the deformation or bending of the slab). Analysis would be of questionable value if not supported by tests, and I have written this partly in the hope of hearing of such tests or inducing some party who is equipped for the purpose to supply the deficiency.

R. G. Doerfling.

872 Monadnock Bldg., San Francisco, Cal., Feb. 7, 1911.

### The Responsibilities of Building Departments.

Sir: The report of the commission appointed to investigate the collapse of the Henke reinforced-concrete building, Cleveland, Ohio (Engineering News, Jan. 26, 1911, p. 117) is most interesting, particularly the supplementary report upon the Building Code of the City. The facts brought out in regard to the inability of the building department properly and sufficiently to check the plans upon which permits are issued and to check finally the work as construction progresses, are pertinent and enlightening.

It is probably true that in most cities the Building Department or Board of Works has insufficient engineering talent in its employ, nor does it employ engineers to approve plans upon which permits are sought. A perfect set of Building Laws will not produce the desired results if they can not be enforced, nor can they be entirely useful if the Building Department give but a cursory examination of plans and specifications submitted.

There is no doubt that more or less close inspection is necessary in all construction, but reinforced-concrete work requires constant inspection and this requirement should be made mandatory. The personal element enters here perhaps more than in any other work, as there is less machine-manufactured material used in structural parts. The effort of workmen is not as uniform as that of a machine and frequently a laborer feels too tired to remove pieces of wood, sawdust, etc., he may see. A night out makes him less ambitious. Rigid inspection is absolutely necessary and should be provided, as most of the structural parts of reinforced concrete are made by labor at the site. A steel frame is more likely to be perfect than a concrete frame, as the manufacture of steel is so standardized that good results are almost invariably obtained, due to the multiplicity of machine methods.

There should be in the building department competent engineers to determine whether or not plans as submitted fulfill the requirements of the building ordinances or the same results might be accomplished by making provision in the Building Ordinance to permit the department to employ the necessary expert service. As suggested in the report on the Henke Building, a commission of building experts could be provided and to them the building department could refer all questions of a technical nature.

It might be argued that too much checking of plans is unnecessary if a proper building code is provided and that architects and engineers should follow code and check their own plans. Many do prepare good plans and in conformity with the Ordinance but at the same time many more probably pay no attention to the Ordinances, but correct plans when ordered to. The building ordinances when properly prepared make good law, but in this case, like everything else, we have plenty of law but not enough enforcement.

The Henke Building report is good and thorough and goes into the responsibilities of the various interests connected directly or indirectly, in the construction of the building. It is to be hoped that the experiences here gained will be useful and the procedure recommended in the report be followed in various cities as well as the city in question.

A. H. Markwart.

San Francisco, Cal., Feb. 20, 1911.

### A Handy Method for Interpolating Contours.

Sir: In looking over back numbers of Engineering News, I find several methods for interpolating contours, and your editorial foot-note following the letter of "M. A. C." in the issue of July 30, 1903, prompts me to send you a sketch and description of a diagram which was recently used in this office on the topographic maps of the Rhode Island Section of the Intra-Coastal Waterways.

The diagram is made on regular Plate A, 4 × 20 profile paper as follows: Take some point on the heavy horizontal line on the lower edge of the paper, at its intersection with a heavy vertical line, as O, and from this point lay off toward the top of the paper an elevation scale of ¼-in. = 1 ft., drawing horizontal lines to the right from the 5, 15, 25, • • • 75-ft. points in red and from the 10, 20, 30, • • • 80-ft. points in heavy black. From the O point lay off to the right a horizontal distance scale of 5 ins. = 100 ft., drawing the vertical lines from the 10-ft. points in red, with the exception of the 50, 100, 150-ft., etc., lines, which are drawn in heavy black.

The rest of the apparatus consists of two needle points, a piece of silk thread and a small weight. The needle points have holes or eyes in them close to the points. They were made from sewing-machine needles with the point filed down fine and a shoulder formed, as close as possible to the eye, similar to the needle point in a bow-pen instrument. This shoulder and fine point were made so that a large hole would not be punched in the diagram when the needles were stuck in hard enough to withstand the pull of the thread.

Fasten one end of the thread to the eye of one of the needle points, pass the thread through the eye of the other needle point, and attach a weight to the end of the thread, letting it hang over the edge of the table as shown in the sketch.

The method of operation is as follows: Suppose we have two points on the map 83 ft. apart at elevations of 3.4 ft. and 17.2 ft., respectively. Run up the vertical line at the left of the diagram from the O point to the elevation 3.4 (A) and stick the first needle point. Run along the horizontal scale to 83 ft. and then up to elevation 17.2 and stick the second needle point. The weight on the thread keeps the thread taut between the needle points. The distance of the 5, 10 and 15-ft. contour points from the initial point are read off directly on the horizontal scale and found to be 10, 30 and 70 ft., respectively.

Only one hand is required to operate this diagram and no mental effort is required such as finding difference of elevation between the two points A and B, as is necessary in some of the methods heretofore described in your columns. By having the diagram on the right of the map work, the needles can be set one after the other with the right hand, leaving the left hand free to hold the scale in position on the map.

On the Intra-Coastal Waterways work, one man working the diagram kept two men busy drawing contours by reading contour distances to them alternately as the elevations and distances between them were called to him. In this case neither of the needle points were sharpened.

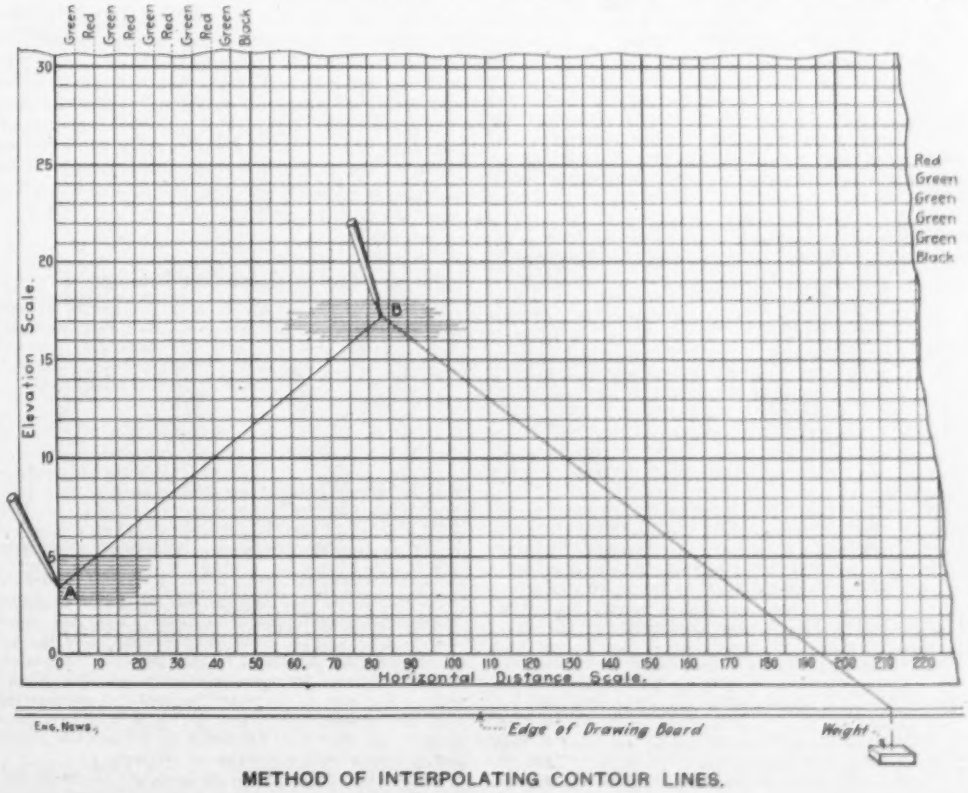
The range of the diagram in vertical scale is 80 ft. while in horizontal scale it can be made as long as desired. Both the scales can be varied to suit the requirements of the work.

Ralph F. Rhodes.

U. S. Engr. Office, Newport, R. I., Feb. 11, 1911.

### The Comparative Resistance to Traction of Boats and Railway Trains.

Sir: In an address made before the National Rivers and Harbors Congress in December last, Mr. F. B. Delano, M. Am. Soc. C. E., President of the Wabash Ry., made the statement that in his opinion less power is required to move a ton of freight on a railway, the grades of which do not exceed 0.3%, than on a canal or a canalized river. Extracts from this address were




METHOD OF INTERPOLATING CONTOUR LINES.

published in your issue of Jan. 5, but the statement above referred to was not included therein.

In a communication published in your issue of Jan. 26, Mr. Delano calls attention to the omission of this statement from your condensation of his address, reiterates his belief in its truth, states that it has aroused much interest among laymen and adds that he has submitted the question to a number of engineers, none of whom were named, but all of whom agreed that he was "undoubtedly correct."

Mr. Delano's statement aroused enough interest in one layman to induce him to make a search through the mass of engineering literature to be found in the Congressional Library and to submit the question to some engineers, who, from the positions they occupied, were presumably qualified to express an opinion.

When Gen. Wm. H. Bixby, Chief of Engineers, U. S. A., was asked if the statement is correct, he replied.

The question cannot be answered in a word, because what is true of one boat and train under one condition is not true of other boats and trains under other conditions. Even if you take a particular boat and train, the question as presented cannot be answered because the vital element, that of speed, is not stated. A gasoline launch of 2 HP., if you would give it time enough, could tow a 6,000-ton ship to its destination in still water. To move the ship at a commercial rate of speed would require much greater power. Whether it would require more power to move a given weight by rail or by water would depend fundamentally on the speed.

To the same effect is the answer given by Naval Constructor D. W. Taylor, U. S. N., one of the leading authorities of the world on naval architecture:

At low speeds Mr. Delano's statement is undoubtedly wrong. A speed can be found where it would undoubtedly be right. In perfectly still water and still air a child could move a 10,000-ton ship; he could not move it very fast and his strength would not allow him to move it very far, but he could move it, while he could not start a loaded freight car at all, to say nothing of an entire train.

Comparisons of the power required to move freight by different methods of transportation are unfair and misleading unless made for a speed which is practicable for all methods considered. Col. C. McD. Townsend, Corps of Engineers, U. S. A., stated in an address delivered at Quincy, Ill., that a team of horses which can haul four tons in a wagon on a paved street can haul more than ten tons in a car running on steel rails, and 200 tons in a canal boat. This indicates that a single horse can haul more than five times as much on rails as on a pavement, and nearly 20 times as much on a canal boat as on a railway.

A study of the literature relating to train resistance reveals an extraordinary difference in the results obtained by different investigators. The paper presented by Mr. J. A. F. Aspinall, General Manager of the Lancashire & Yorkshire Ry., before the International Railway Congress, and printed in the Bulletin of that Association in May, 1903, gives no less than 55 formulas for train resistance which had been obtained by various observers, and one of the engineers who participated in the discussion added five more. In the introduction to his paper by the editorial committee it is said

of all the problems set before the railway engineer that of train resistance is one of the most difficult and complicated and for this reason it has for many years occupied the attention of many able minds.

The committee points out the fact that a formula can be depended upon to apply only under conditions exactly like those under which it was deduced. When we turn to the records made by dynamometer cars we find that tests made under apparently identical conditions give widely varying results. Bulletin No. 43, issued by the University of Illinois Engineering Experiment Station states that

differences were observed, amounting, in some cases, to 23% between single observations in connection with individual tests and the mean of all the observations made during that test. . . . . Some tests show great and persistent variation from the mean at various speeds for which no plausible explanation was found.

The author of this bulletin states that his results differ in some cases by as much as 20% from the result of tests on the Pennsylvania R. R. and by 35% to 60% from those obtained on the Chicago, Burlington & Quincy R. R., the tests in all these cases being made with cars of recent design and taking into consideration the influence of varying weights. All this is calculated to make a layman wonder if Mr. Delano knows exactly how much power it takes to move a given weight by rail.

The latest, and presumably the most authoritative, compendium of engineering information is the "American Civil Engineer's Pocket Book," issued in January, 1911, and edited by 15 of the best known engineering experts of the United States. In this it is stated that train resistance at moderate speeds is from 4 to 8 lbs. per ton, while dynamometer tests made on the Seine, in France, showed the resistance of the type of boat called a Prussian barge, when towed at the rate of 3.33 miles per hour, to be 1.95 lbs. per gross ton. These were small boats, with a gross tonnage of only 210 tons. The larger the boat the less the resistance per ton, for total resistance increases much less rapidly than carrying capacity. Captain Austin M. Knight, U. S. N., in his work on "Modern Steamships" states the approximate resistance of a vessel having a displacement of 5,700 net tons, when towed in smooth water at 4 knots an hour, is 3,800 lbs., or ⅔-lb. per ton.

As speed is increased, however, vessel resistance increases more rapidly than train resistance and it is evident that sooner or later, varying with the shape of the boat and its size, both absolutely and relative to the channel in which it operates, a speed can be found at which train resistance is less than vessel resistance. But this statement, while true, is unimportant, except in so far as standing alone it may mislead the general public as to the relative efficiency of railways and waterways as agencies of transportation. There is no more necessity for boats to compete with trains in speed than for wagons drawn by horses to do so.

In the movement of much the larger proportion of materials offered for transportation, the vital factor is not speed but economy. For any canalized river, large enough to be seriously considered, there can be developed a type of boat adapted to its navigation; for this typical boat there can be determined what may be called a normal speed; and by this typical boat and at its normal speed freight can be transported with a frictional resistance less than that of a train at any speed, with an economy which is unapproachable by the railway, and this freight can often be delivered in less time because the motion of the boat, while less rapid than that of a train, is more continuous.

The truth is that wagon roads, railroads and waterways have functions which are essentially different. Each one of them can meet a need which neither of the others can fully supply. The resources of the country cannot be developed to their ultimate possibilities unless all three forms of transportation are available, and since prosperity of railways depends upon the prosperity of the people, rather than vice versa, as some railway men would have us believe, it follows that railway men who oppose the development of American waterways are, whether consciously or unconsciously, working in opposition to the true interests of American railways.

S. A. Thompson.

[There are some statements which are said to be "important if true." There are others which even if true are of trivial importance. The question discussed by our correspondent comes under the latter head because the cost of the power used in either rail or water transportation is a very small item in the total cost. As we understand it, however, Mr. Delano was comparing the resistance of modern freight trains run at economical freight train speeds with the resistance of vessels on inland waterways run at speeds which are essential for economy in modern waterway transportation. Under these conditions the resistance per ton of modern high capacity freight cars has become very low, while as the resistance to the movement of vessels varies approximately as the cube of the speed, a point is soon reached where the unit resistance on water is as great as on a rail.

However, it is not the cost of the power, but the total cost of transportation, including terminal expenses, insurance, responsibility of the carrier and the interest and maintenance expense which determine whether rail or water transportation is the more economical. The results of actual experience in the United States during the past two decades do not bear out Mr. Thompson's claim for the greater economy of the inland waterway over the railway.—Ed.]

## Cost of Calyx Core Drilling.

Sir: The following figures give the results of four test holes made in an argillaceous slate rock with clay seams, covered over with earth of a coarse gravel nature:

| Hole | Earth. | Rock. | Total Depth. |
|---|---|---|---|
| No. 1 | 12.0 ft. | 15.0 ft. | 27.0 ft. |
| No. 2 | 5.0 ft. | 19.2 ft. | 24.2 ft. |
| No. 3 | 5.4 ft. | 50.4 ft. | 55.6 ft. |
| No. 4 | 13.7 ft. | 56.7 ft. | 70.4 ft. |
| | | | 177.2 ft. |

| | |
|---|---|
| Cost of hauling drill to and from work (23 mi.). | $30.00 |
| Cost of hauling 7½ tons coal 6 miles at $2.00.... | 15.00 |
| Coal, 7½ tons, at $5..... | 37.50 |
| Hauling water from ¼ to ¾ miles..... | 99.25 |
| Labor, drillman, $3, fireman $2.50..... | 217.40 |
| Board for drillman and fireman, 39 days..... | 48.00 |
| 177.2 lin. ft. at $2.52 per ft..... | $447.15 |

The size of the core removed was 2¼ ins. in diameter. Considerable trouble was encountered where clay seams were found. The bit would become clogged and the action of the steel shot would be very slow. In such cases, the bit was removed more frequently and cleaned, and more water used to carry off the mud. A steel casing was used through the gravel to the rock and a large part of the time was consumed in driving the casing and making a tight connection at the rock.

The personal factor of the drillman was the main feature in getting results on the work, as he had to contend with large boulders in the gravel, and [illegible] seams in the rock. The results obtained by this m[illegible] were satisfactory, and the expense was close to t[illegible] original estimate.

H. C. Kittredge, Assoc. M. Am. S[illegible] E.
815 German Insurance Bldg., Rochester, N[illegible] Feb. 6, 1911.

## "The Subway Ear."

Sir: In a recent issue of the "Saturday Even[illegible]post," which does not knowingly use incorrect or m[illegible]ding statements for holding the interest of its read[illegible]there appeared a little article with the above title, in [illegible]ch it was stated that those who habitually ride in th[illegible]ubway are having their hearing impaired by the air [illegible]ssure to which they are subjected. "To provide the [illegible]uisite ventilation," it was said, "air is continually f[illegible]d into the underground tunnel. Consequently the a[illegible]n the subway is at a pressure considerably greater [illegible]an outside. When a person descends into the tube [illegible]ear-drums are bulged inward; when he leaves the t[illegible]nel the sudden removal of pressure causes them to b[illegible]e outward. This, when often repeated, is liable to [illegible] up an irritation, which in turn may bring about catarrh, etc., etc."

Now it may be true that riding in the subway does have a deleterious effect upon the hearing, but not on account of the increase of air pressure, for there is no such increase. The other day I put my little pocket aneroid in my pocket, entered the subway at 125th St. and Lenox Ave., and rode continuously to Bowling Green, say about eight miles. Going down from the sidewalk to the station platform there was an increase of pressure represented by 0.04 in. of mercury, or say 0.02 lb. per sq. in. In all the trip there was no increase of pressure above this. In fact the pressure began to fall, but the greatest fall was only 0.10 in. of mercury, or say 0.05 lb. The somewhat lower pressure, within this slight range, continued through most of the trip, the final reading on the Bowling Green platform being identical with that at 125th St.

It may be contrary to the popular impression, but there is no artificial forcing of air into the subway. The fans which were tried for the purpose did not produce satisfactory results and, as narrated by Dr. Soper in his excellent Boston paper upon subway conditions,* their use was discontinued, relief having been ultimately found by making large openings between the tunnel and the outer air, and through these, as Dr. Soper says, the tunnel "breathes" both inwardly and outwardly. The tunnel pressure is the same as that outside except for the slight difference due to the difference of altitude.

In riding up or down in the elevator between the sidewalk and my room on the 14th floor, where these lines were written, the barometer showed a change of pressure just double that observed in the eight-mile subway trip.

Frank Richards.
Managing Editor of "Compressed Air."
11 Broadway, New York City, Feb. 21, 1911.

## A Criticism of the Swatara Creek Bridge, Hummelstown, Pa.

Sir: In your issue of Jan. 26, 1911, p. 103, in an article entitled "A Heavy Concrete Bridge Built to Resist Ice Pressure," by Mr. Mason D. Pratt, you show a five-span concrete bridge that is an excellent illustration of the optical illusion that distorts a bridge of several equal spans.

In my study and observation of the design of concrete arch bridges I have found that one of the first motives of the design is to eliminate all elements of a delusive nature in the general lines of the arches taken as a whole. From the illustration of this particular bridge, the appearance to the eye is very pronounced of a short middle span with increasing spans towards each end, which seems to me is faulty design. Obviously the middle span of a long arch bridge should be the main span and the dominating span, whether for appearance or for economy and utility. If the designer wishes to give the appearance of equal spans he should design with the longer span at the middle to oversome the apparent illusion. Properly the spans should be so varied that the illusion will be more than overcome, and the middle spans shall appear the dominating spans. Parallel cases can be cited, though not in this instance, where camber should have been provided to overcome the apparent deflection due to an optical illusion. In the case of the Hummelstown Bridge illustrated, the difference in lengths of spans would have need to be pronounced, as much as 10 or 15 ft., say, to overcome the illusion. Again, the camber of several feet shown appears to me to add to the importance of varying the spans and gives one the impression of unbalanced thrusts, that of the middle span being least and that of the end spans being greatest, just the reverse of what efficiency would dictate.

I do not understand the reasoning by which the design for resisting ice was arrived at. Ice jams, from my

*See Engineering News, Nov. 9, 1905, p. 493, and March 8, 1906, p. 263.

observation, do not form against bridges located immediately below dams. If an ice jam formed against the old bridge it would seem that the jam must have formed against obstructions such as wooded islands downstream and then must have backed up under the steel bridge lifting it from its abutments or piers. It hardly seems reasonable to foresee a jam against the piers of a steel bridge located 300 ft. below a dam that would naturally shatter the ice field before reaching the bridge. But if the jam forms below the bridge and exerts upward pressure on the arch, it would seem that a reinforced structure in concrete bound together with embedded steel from end to end would have every advantage over the plain concrete arch that was adopted.

I do not understand either how reducing the length of the piers can increase the weight of the structure. I had supposed it elementary that for a given waterway the shorter spans would result in reduced weight.

Another criticism that occurs to me on reading the description is that filling the spandrels full of concrete to increase the weight is hardly an improvement in design for any purpose whatever and that its effect in resisting ice in that particular location is practically nil. It hardly increases the weight of the structure 10% over an earth fill whereas it must have increased the cost 20%. If there was an abundance of quarry stone available, as mentioned, it is difficult to see why they could not have been bedded in the earth fill quite as effectively as in cement mortar. The inference is drawn that several barrels of cement were used to increase the weight of the bridge, whereas the same results could have been obtained by using the available quarried stone and gravel with an increase in the depth of fill over the bridge of less than one inch.

Your contributor adds that the concrete filled spandrels provides a secure foundation for the pavement over the bridge. It would seem a hardship for any community to have to build its brick pavements on a concrete foundation 10 ft. thick to prevent settlement, but the reason has more force than the argument regarding ice pressures and impact. However, it brings to mind instances of arch bridges that have been designed for country highways far removed from paved streets in which, nevertheless, the designer has required the bridge to be paved. In the Hummelstown Bridge, under discussion, the structure must have been on a continuation or close proximity of a paved street, otherwise there would be no argument for paving the bridge. The traffic over a bridge 17 ft. wide is not necessarily more congested than over the approaches, for there is room for two lines of vehicles and the roadway over the bridge has every advantage over the neighboring roads in that it is readily drained through the arches, both for seepage and surface water. The above points are mentioned in the argument against paving any isolated piece of highway over a concrete bridge.

The former points of discussion are along lines questioning the desirability of envolving the exceptional features and departures from the usual practice for such bridges.

H. E. French.

Baraboo, Wis., Feb. 18, 1911.

[We have submitted the above criticism to Mr. Pratt, and have had from him the following reply.—Ed.]

Sir: The criticism of Mr. French is only another illustration of the reason why photographs are always looked on with suspicion when produced in evidence in court and shows how easy it is to create a wrong impression by selecting a suitable point of view. The illustration accompanying my description of this bridge undoubtedly gives the false impression to which Mr. French objects. It would also appear from this view that one end of the bridge is much lower than the other, whereas both ends are at the same elevation. Generally a bridge is seen by the traveling public from a more or less acute angle and in such cases the far spans appear much smaller than the near ones. It is manifestly impossible to correct this impression in the design. I enclose another photograph of the bridge [not shown here—Ed] taken from one of the roads approaching the bridge which gives an entirely different impression and when the rules of perspective are applied clearly shows that the structure is of a number of equal spans.

The dam immediately above the bridge is a timber structure having a broad and comparatively flat apron downstream so that in flood conditions comparatively large cakes of ice will pass the dam and approach the bridge with considerable velocity and the usual construction of comparatively light spandrel walls with earth backing did not appeal to me as being consistent with a permanent structure. The use of lean gravel concrete in the spandrel filling increased the weight of the upper-superstructure 25%, and not 10% as stated by Mr. French, and did not increase the cost of the structure over 2½% instead of 20% as estimated by Mr. French.

As stated in my description, the bridge was built by the State of Pennsylvania to replace one of the flimsy structures so common in county bridges and while the structure is possibly in some respects a better one than is warranted by the location, my desire was to show that a substantial, durable and ornamental structure if honestly built, could be constructed at comparatively low cost and from this point of view I may perhaps be pardoned for believing it a success.

Mason D. Pratt.

16 South Market Sq., Harrisburg, Pa., March 3, 1911.

## The Solution of a Surveying Problem by the Use of Coordinates.

Sir: I have recently worked out the solution of a special case in land surveying where the advantage of the use of rectangular coordinates is easily demonstrated. While there is no claim made for any new theory the solution may prove beneficial to others in dealing with a similar problem.

Referring to the accompanying sketch, the Blue Line is the outside boundary line of the Erie Canal State property. The conditions were as follows: The parcel lay in a densely wooded swamp; the right-of-way was parallel to a curved line that had been recently changed, and the only established points in the field were on the Blue Line (B. L.) and the P. T. hub. The curve was 4,000 ft. long, and could be located for the parcel only by running 2,000 ft. of it through dense woods and swamp covered with deep snow, and checking on some base line point before setting intersections or ties to the points *A* and *B*.

The B. L. had been run the previous summer and the coordinates of the points established. In the worst of the winter a rush order came to make the survey of this parcel for immediate appropriation.

In the open country property lines are seldom better located than by irregular fences, stone walls or a line of trees. In this case the lines were marked only by the division between a second growth cedar swamp and a cleared area grown up to brush. Their ranges were therefore established by eye and the points *C* and *D* quickly set on the B. L. line.

The method then followed was: Set up at the B. L. hub nearest intersection of B. L. with the property lines and orient from other B. L. hub and read the azimuth and measure the distance to *C* and *D*, as *EC* and *ED* (it may not be possible to get both from one set up). Set up at *C* and *D*, clear along the lines *DA* and *CB* enough to set hubs on them, then read the azimuth of these lines, and the field work is done for the present—a couple of hours work.

In the office: Compute the coordinates of *C* and *D* from measured ties from B. L. point or points. From center line data compute coordinates of *O*, which is the center of the circle whose arc is a 2° curve. The solution of the three remaining sides is as follows: The difference of the coordinates of *O* and *D* gives the sides of a right angle triangle with *OD* as the hypotenuse, so the length and azimuth of *OD* are readily computed; the difference of the azimuths of *OD* and *AD* gives the angle *ADO*. Then with *OD* known and *OA* = *R* — 150 ft., we have:

$$\text{Sin } DAO = \frac{OD \text{ sin } ADO}{AO}.$$

$AOD = 180° - DAO - ADO$, hence the azimuth of *AO* or *XO* is determined.

$$AD = \frac{AO \text{ sin } AOD}{\text{sin } ADO}.$$

Hence we have the distance and azimuth *AD* and can compute the coordinates of *A*.

By exactly same method compute the coordinates of *B*, and the distance or chord *AB*. The difference of azimuth of *AO* and *BO* = *AOB*.

The long chord $AB = 2\ (AO \text{ sin } \frac{1}{2}\ AOB)$.

By chords $XY = \frac{100\ AOB}{2}$. Then $AB = \frac{XY\ (R-150)}{R}$.

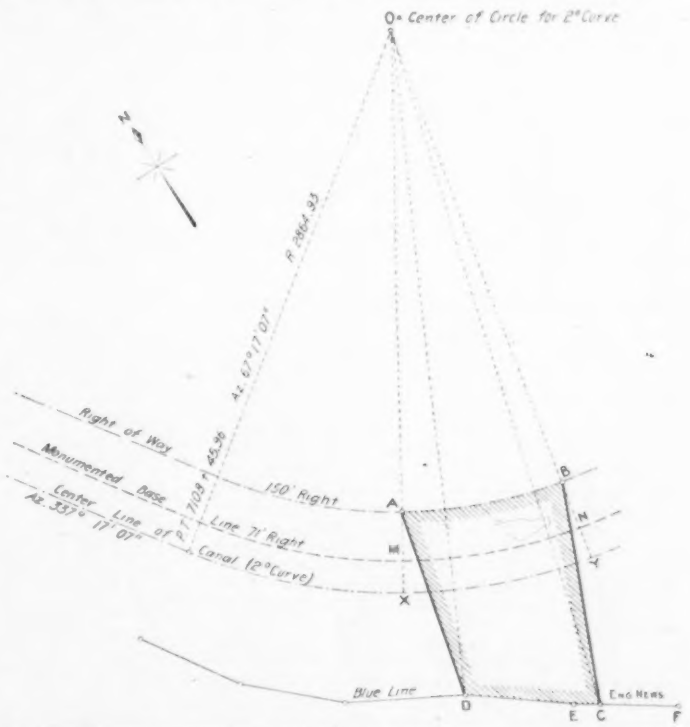
Or the arc $AB = \frac{\pi\ (R-150)\ AOB}{180}$.

To find the station of *X*:

The azimuth of *XO* — azimuth of (P. T.)-*O* = the angle *XO* (P. T.).

$\therefore$ The station of $X = 7{,}108 + 45.90 - \left(\frac{100\ XO\ (\text{P.T.})}{2}\right)$

and the station of *A* = the station *X*. Similarly the station of *B* may be found.




A SURVEYING PROBLEM SOLVED BY THE USE OF COORDINATES.

The lengths and azimuths of all the sides are then known. The computations are not as long as the description would indicate. The latitudes and departures of *AD*, *AB* and *BC* computed in the foregoing would necessarily have been computed in solving for the area. There are also the ties (*AM* and *BN*) required for the parcel and the adjoining one on either side to tie to the permanent monumented base line 71 ft. to the right of the center line. Also from the foregoing computations we have the azimuth of *XAO* and *YBO* and the ties are completed by the distances *MX* or *NY* = 150 ft. — 71 ft. = 79 ft.

It is evident that there is but little more office work required than there would have been if *DA*, *AB* and *BC* had been accurately measured in the field. The parcel is complete in far less time and entirely independent of weather conditions, which are frequently a serious and prolonged handicap to rush work, especially in winter.

At some later date as the occasion may require, when the map of this parcel is completed and everything is well along in the red tape machinery of appropriation, the field party will set the hubs at *A* and *B*. To do this set up at *D*, foresight on line hub used for *AD* when that line was cleared and azimuth read, then measure the computed distance and set hub or monument. Do the same for *CB*.

Another advantage in the use of coordinates is that in the case the hubs on the *DA* and *CB* lines are knocked out, a tie from any other near established point is readily figured and the points set as required. The check on the work is in the area computation, and any error, if there is one, must have been in the original field work.

B. Le G. Rees, Asst. Engineer,
Barge Canal Contract No. 77.

Palmyra, N. Y., Feb. 20, 1911.

## The Best Pipe for Laying in Salt Ground.

Sir: In reply to the letter of Mr. Oscar Ribeiro which appeared in Engineering News of Feb. 16, 1911, the writer believes that wood pipe is the best pipe to use to carry water through salt marshes or through salt water.

Salt has no decaying effect upon wood, and if the pipe is wound with copper wire, it would last much longer in salt water than cast iron or steel.

The writer would call Mr. Ribeiro's attention to the new wood pipe pumping main laid across seven miles of salt marsh at Atlantic City, N. J., to take the place of the steel main laid in 1901, which has become badly pitted from the action of the salt water, and the cast-iron main laid about 1892, which has also become pitted in spots.

This main is 48 ins. in diameter and is made of wood staves 2 ins. in thickness, banded with wrought-iron bands ⅝-in. thick. The pipe withstands a pumping pressure of about 73 lbs. per sq. in.

Long Beach and Elmhurst, L. I., also have wood pipe laid through salt marshes for the purpose of carrying fresh water. The latter is 20 ins. in diameter, 2,000 ft. long, and is operated under a pumping pressure. Wood pipe was used in each of these installations because it

was feared that cast iron or steel would soon become corroded.

Wood pipe 5 ins. in diameter is made of wood staves planed to an even thickness of either 1½ ins. or 2 ins. The staves are cut from either white pine, cypress, red wood, Oregon fir or maple, and the pipe is made in sections from 5 to 12 ft. long. The joints are connected by a machine-made mortise and tenon, so that the tenon can be driven into the mortise making a water-tight joint under pressures up to 150 lbs.

Under ordinary conditions the staves are banded with steel bands 1 in. wide and of 18 to 24 B. W. gage, depending upon the pressure the pipe has to withstand. Where corrosion is expected copper wire has frequently been used with entire satisfaction. For pumping mains in copper and coal mines, copper bands have been much used.

The weight of 5-in. wood pipe with staves 2 ins. thick and wound to withstand 80 lbs. pressure would be about 10.5 lbs. per lineal foot; whereas the weight of cast-iron pipe 5 ins. in diameter for an 80-lb. pressure would be about 25 lbs. per lineal foot.

Concrete can be used successfully to prevent corrosion of pipes from the action of salt water, or from other causes. The cement should be mixed with about two parts sand and five parts gravel, and densely packed about the pipe in a 4 to 5-in. envelope. Joints between the concrete envelope should be made at such equidistant length as to provide for the expansion and contraction of the concrete. In this latitude 30 ft. is about right. A thin copper sheet, 4 ins. wide, should be inserted in the ends of the concrete at the joints, to prevent leaks either in or out.

Concrete envelopes have been placed about steel and cast-iron piles, or columns, to prevent corrosion from salt water, at Atlantic City and San Francisco, and have proven satisfactory.

In the writer's opinion the answer to Mr. Ribeiro's third query would be to lay 5-in. wood pipe with copper wire bands. It could then be examined and repaired at any time.

T. Chalkley Hatton, M. Am. Soc. C. E.

Wilmington, Del., Feb. 20, 1911.

## Negative Arguments in Favor of Licensing Engineers.

Sir: The writer is not in the least surprised to note in your issue of this week that "a number of leading engineers" express themselves as opposed to licensing engineers. Probably no advocate of the license will claim that the license can be of any use to the leaders. It is aimed to benefit the engineers in the large intermediate class between the leaders and the mere subordinates, the middle class of engineers, and likewise the general public. Furthermore it is doubtful whether these leading engineers have fully informed themselves as to what a license law really is, especially what the McGrath bill is. This may be readily believed when one sees how far astray the Engineering News itself may go and how imperfectly its editor understands the meaning of this bill.

So far as placing the operation of the law in the hands of the Regents is concerned, the McGrath bill merely follows the lead of all the other professions that are now licensed by the State, with the exception of Law. The workings of these laws, especially the medical license law, have shown no disadvantages due to their control by the Regents. There are sometimes uses for the ripe judgment of patriarchs, especially when they are men of unimpeachable integrity, who give their services without any remuneration from the State. The Regents are both the fly-wheel and governor of this legal engine and by their very inertia will prevent dangerous "racing." [!] Better far the Regents than a group of politicians, even political engineers.

It may be stated with little fear of contradiction in answering your query as to what is "holding himself out," that the applicant for a job as draftsman does not "hold himself out" to be a structural engineer within the meaning of the law [?]. The chief draftsman of a bridge company needs the protection of no law to prevent the incompetent from taking improperly any of his employer's money. What is plainly intended is that an engineer claims to be such only when he "holds himself out" as competent to the uninformed lay public.

Apparently the Editor had not read the McGrath bill carefully when he made the statement that "apparently the well meaning young men who framed the law are anxious to confine all engineering work to the men who have graduated from engineering schools" so that "there would be no chance, therefore, for the young man who is, through force of circumstances, deprived of the opportunity of obtaining a regular engineering education." The copy of the McGrath bill before me, which I would urge all interested to obtain through the Clerk of the Assembly, provides very clearly on page 6, Section 1206, subdivision 5, "Or the regents shall accept, as the equivalent for any part of the fourth requirement above named" (graduation from a reputable engineering school), "evidence of five or more years' reputable practice." The sixth requirement permits the licensing of engineers graduated or licensed abroad.

As to the further lament of the Editor that because there are and always will be "men endowed by nature with the qualifications which bring great success in engineering work," it will be a sorry day when a man is "forbidden to practice simply because he has not had a certain preliminary education," it may be asked has the medical license law, which limits the license to graduate physicians, prevented or even hindered the activities of a Pasteur, who was not a graduate? Would any law restrain the genius of an Edison, who never graduated?

We can best judge the future by the past. Admitting that there are twenty-five specialties in engineering and supposing the law would certify to a licensee's competence in all, which of course no law can ever do, are there not specialties in medicine, too, and does the State certify that every physician is an expert surgeon, an expert oculist, an expert gynecologist, an expert in pediatrics, obstetrics and orthopedics? If the State does so, does any one take such an endorsement seriously? Why then would the public be easier deluded in the case of the Engineer?

True enough there may, as you say, be in the bill "nothing whatever to prevent the holder of a certificate who, after some experience in structural work, finds himself out of a job, hanging out his shingle as a Sanitary Engineer," but pray, what is there now, without a law to prevent him from doing the self-same thing? Presumably, having passed a license examination at one time in his life, an examination which required, among other things, some knowledge of sanitation, he may remember some small fraction at any rate of what he will need to know in his new work. At present he can hang out his shingle if he pleases and still be entirely ignorant. It need not be supposed that the general public will lose all its common sense because there is a license law, and come to employ any one who hangs out a shingle. The public, if it ever does such a thing, will still be a little better off, if only a little, with the law than without it.

There certainly is "a very large number of doctors and lawyers possessing a state license and yet unable to practice their profession," but suppose their protecting license laws were repealed so that the very large number of engineers who are unable to practice their profession could decide over night to became doctors or lawyers, how many more poor doctors and lawyers would there be driven to the wall by such unfair competition, and how would the public be affected in health and pocket?

The argument that the license will not help to raise the profession because besides doctors and lawyers, also barbers and saloonkeepers—yes, and dance-halls and dogs—are licensed, is simply based on the verbal perversion of assuming that "license" means always the same thing and that all licenses produce the same effects. As well say the cadets at West Point have nothing to be proud of in their uniforms because policemen and motormen wear uniforms, too, and so do street cleaners and even convicts.

The law does not pretend to enable the public to select the best and most trustworthy men for any and every engineering work, but it is expected to improve conditions by weeding out in time the utterly incompetent and so benefiting the public to some degree at least.

Very truly yours,

Isaac Menline.

New York City, March 10, 1911.

## Postage Rates on Magazines.

Sir: Referring to the editorial articles in Engineering News of Feb. 16 and 23 on the proposed increase in rates of postage on the advertising pages of periodicals other than newspapers: Why not go farther in your arithmetic and publish in the Engineering News your charges for one page per issue, also per year for advertisements, your yearly gross earnings, expenses, profits and dividends, instead of belittling the service rendered by the railroads and giving us so much arithmetic and hypothetical data about their earnings?

One often hears it asked: "Why rob Peter to pay Paul?" Pray: what service do even the best magazines, let alone muck-raking kind, render the country in comparison with the service rendered by the railroads that the earnings of the railroads should be reduced to compensate the magazines, which are telling us the increased postal rate will be charged to the advertiser, the people, and the railroads of the United States which every year pay six to seven million dollars advertising?

The magazines, for some time, have been taking great delight in criticizing the railroads, explaining how poorly they are operated, how easily they can be managed, what enormous profits they make, etc., etc., but oh, what a mighty wail went up as soon as the shoe began to pinch their own feet!

The politicians have long worked the trick of deflecting the attention from a trying situation or the main issue by directing it to something else, but different treatment is expected from a magazine that we would long hesitate to class with the kind that advertise "The whole thing is unfair as Hell."

Why not start a crusade to improve the quality of the majority of our magazines, for it is a common saying that many of them are replete with trash.

In this connection it might be interesting for the Engineering News to give us some light on the [illegible]ation of the present high cost of living due to so mu[illegible]ivertising and such high rates for it.

Yours truly,

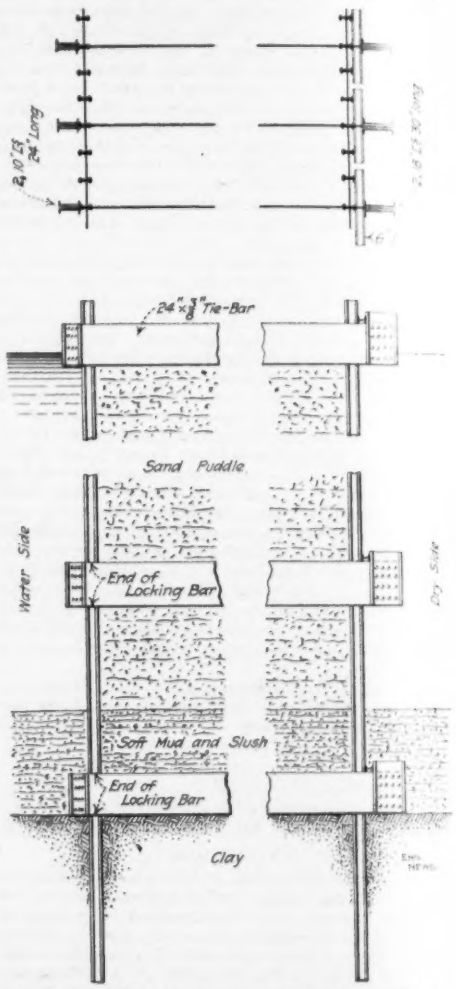
Wm. F[illegible]lin.

1043 East State St., Trenton, N. J., March 7, 1[illegible].

## A Proposed Method of Placing Tie-B[illegible] in a Steel Sheet-Pile Cofferdam.

Sir: Herewith is a plan of a deep-water [illegible]rdam which the writer believes to have some intere[illegible] features.

The main feature of this dam is that it [illegible]d together below water, in a simple manner, w[illegible] will prevent bulging or kicking out at the toe of [illegible] sheeting, a trouble common in deep dams. By [illegible]g the type of steel sheeting shown, the wall can b[illegible]ed together in the following manner: Drive both [illegible]alls as usual, except that every third interlock is pu[illegible] in place




Steel Sheet-Pile Cofferdam With Steel Tie-Bars Placed in Interlock Space.

but not driven; after walls are driven pull out the third interlock and replace with an 8-ft. piece, this being the penetration desired. The 8-ft. piece of interlock is driven down, using a long piece as a follower and then the tie-plate is put in; then another short interlock and tie-plate, and repeat as often as desired.

A 6-in. I-beam is used on the dry side of the dam as a waling, but none is used on the water side.

The plan shown was made for a job which did not go through, and has not been used. But I have used the same ideas in a wooden cofferdam where Wakefield sheeting was used. The bottom was too hard to get penetration enough to hold the sheeting, and to prevent kicking out at the bottom we put in rods with divers. The rods held it all right, but divers are costly and rather uncertain. In the plan shown here, however, everything is done from above water.

F. J. MacIsaac.

612 Judson Ave., Evanston, Ill., Feb. 6, 1911.

## Credit for the Design of the Gatun Locks Construction Plant.

Sir: I was very much interested in the splendid article on the "Construction Plant at Gatun," written by Messrs. Schildhauser and Lee in your issue of Feb. 16, as I am familiar with the original plans of the layou[illegible]

Your editorial brings out the fact that this plant has worked successfully and has handled an enormous amount of concrete; and as it is one of the greatest plants in the world to-day, I think it would not be amiss to give the credit for this plant to those who designed it.

The plant as it is to-day, with some exceptions, was designed under the direction of Mr. Jno. F. Stevens, then Chief Engineer, by Mr. F. B. Maltby, at that time Division Engineer, and his assistants were Mr. G. M. Wells and Mr. T. O. Taylor. Mr. Wells is still at Gatun, and is connected with this work. Mr. Taylor is an electrical engineer and designed some of the electrical appliances.

These plans include the wharves, the quarries and crushers at Porto Bello, the wharves and unloading plant at Gatun, the deepening of the old French canal from Cristobal to Gatun so that material could be transported to Gatun by water, the cableways, storage ground, cement sheds, mixing plant, electric railway, power plant and the cableways that span the locks.

These plans were practically completed before Mr. Stevens left the Isthmus. When Col. Goethals took charge as Chief Engineer, Col. Sibert, Major Harding, Mr. Schildhauer, Mr. Wells and others took up this subject again and after devoting about one year to the study of construction plants, the original plans were finally adopted with some modifications as to details. Col. Sibert enlarged the plant to such an extent that its present output is probably 100% greater than the original plant. This was made necessary by the changes in the lock designs which increased the amount of concrete from 1,300,000 cu. yds. to 2,085,000 cu. yds.

Wm. Gerig.

Pacific and Eastern Railway, Medford, Oregon, Feb 22, 1911.

## The Late J. T. Fanning.

Sir: I note in your obituary on the late J. T. Fanning a reference to the encouragement he gave to the young engineer. I have known him intimately since his coming to Minneapolis in 1885; had an office in same building for many years. A more kindly man never lived. I fear we of the profession imposed on him many times, which he seemed to encourage. It used to be a kind of standard with us, when against some knotty point, ask Mr. Fanning. He was never so busy that he would not cheerfully, candidly and gratuitously give us the benefit of his sound judgment.

He certainly left none but friends in Minnesota.

E. T. Abbott.

Pokegama, Ore., Feb. 26, 1911.

## Notes and Queries.

Supplementing the information on the Toronto Water Filtration Plant, which appeared in our issue of March 9, we give the following additional figures from Mr. Francis F. Longley, author of the article, the figures having been sent at our request, but not early enough for inclusion with the article:

Each of the twelve filter units has a net area of .8-acre, making a total of 9.6 acres, designed to operate at 5,000,000 Imp. gals. (6,000,000 U. S. gals.) per acre per day. This gives a total nominal capacity of 48,000,000 Imp. gals., or a probable working capacity of about 40,000,000 Imp. gals. There is a pure-water reservoir of 7,500,000 Imp. gals. capacity; a low-lift pumping station, electrically operated and with steam auxiliary; a piping system of concrete and cast-iron pipe; sand storage bins and sand washers; a complete drainage system and an office and laboratory building.

## Commission Plan of City Government Propaganda in New York and New Jersey.

By far the larger number of the one hundred or more cities which have adopted the commission plan of city government during the past few years are located in the Central or Far West. There are, however, a few in Massachusetts, and legislation is now being earnestly sought which will make possible the adoption of the commission plan in the States of New York and New Jersey.

The movement in New York State has progressed to such an extent that the Commission Government Association of New York State was recently formed by representatives from 22 cities. The Secretary of this organization, as also of the Commission Government Association of Buffalo, N. Y., is Mr. Ralph Bowman, 1048 Ellicott Square, Buffalo. It is interesting to note that at the New York State conference just named the following cities were represented:

Albany, Auburn, Batavia, Brooklyn, Buffalo, Elmira, Fishkill, Hornell, Ithaca, Jamestown, Lockport, Niagara Falls, North Tonowanda, Ogdensburg, Oswego, Poughkeepsie, Rochester, Saratoga Springs, Seneca Falls, Syracuse, Watertown, Yonkers.

The constitution of the New York State Association states that the object of the Association is to establish in municipalities of the state "a business form of government on the commission plan." Provision is made for yearly meetings, and any municipality in the state may be elected to membership on a majority vote of either the Association itself or its executive committee. It may be added that the President of the Association for the ensuing year is Prof. H. C. Fairchild, of the University of Rochester.

In New Jersey, chambers of commerce and other local organizations have joined in formulating bills for the commission plan in that state. In addition, several cities have drafted bills on their own account and had them introduced in the legislature. At one of the several New Jersey conferences representatives were present from Jersey City, Newark, Hoboken, Trenton, Camden and enough other cities to bring the total up to 16. A preliminary draft of a bill was approved at one of the conferences, referred to a committee of lawyers, and on being reported back to a subsequent conference was approved and finally introduced in the Legislature. The bill as formulated is substantially the same as that drafted and introduced on behalf of several cities, and the purpose seems to be for all parties interested to unite to secure the passage of a single bill which will take the nature of a brief commission-plan city charter, which may be adopted by any municipality in the state after petition and ratification by popular vote. To meet the ideas of some of the New Jersey cities or their representatives which are inclined to look askance at the initiative, the referendum and the recall, two commission-plan bills have been introduced in the New Jersey Legislature, one with, and the other without, the features just named.

Reverting now to action in New York State, it may be noted that under the so-called "public opinion act," which permits any municipality to give by popular vote an informal expression in favor of or against any public measure, the cities of Buffalo and Mount Vernon gave their approval to the commission plan at the Fall elections of 1909. Commission plan charters for each of these two cities were introduced in the New York Legislature of 1910, but failed of enactment. A bill providing for a commission plan charter for Buffalo has been introduced in the present session of the New York Legislature. This persistent movement on the part of Buffalo is of particular interest in view of the relatively large size of that city as compared with any which have thus far adopted the commission plan. It is interesting to note in passing to the consideration of the main provisions of the Buffalo bill that the bill has been endorsed by the Buffalo Chamber of Commerce by a vote of 328 to 32, and that it has also been endorsed by 22 other local organizations.

The Buffalo bill provides for five councilmen, one of whom shall be mayor, each to serve for terms of four years. These councilmen will be vested with all powers and duties heretofore imposed upon the mayor, the city council and the various departments, boards and commissions of the city, "and all other officers of the city whether elective or appointed," with the exception of judges and officers of the city court, the civil service and grade crossings commissions. Even the educational affairs of the city would be under the control of this five-membered council. Under the Buffalo bill the mayor would be the head of the department of public safety, and thus in control of the police, fire and health services of the city. The bill provides for the initiative, the referendum and the recall, and in general contains the other usual provisions of commission-plan charters.

The Lockport Board of Trade, of Lockport, N. Y., stands sponsor for what it terms "an optional third-class cities law," open to adoption by any one of the cities of Albany, Auburn, Batavia, Brooklyn, Buffalo and Elmira which have populations under 50,000 by the latest State Census. This suggested law embodies virtually a commission-plan charter, but the five commissioners or councilmen would be restricted largely or wholly to legislative functions and would appoint a city manager, who in turn would make all other appointments and in general would be responsible for the executive and administrative work of the whole city. In accordance with this idea, the proposed optional law is described as "The Board of Directors Plan."

An interesting pamphlet outlining this plan and giving the proposed law in full may be obtained on request from Mr. Richard S. Childs, 381 Fourth Ave., New York City. As is stated in the pamphlet, third-class cities in New York State are now governed by a variety of "special charters, some good, some bad, all different and calling for continual amendments by the Legislature." The proposed optional law would enable any city to adopt this modified form of the commission plan of city government with a minimum of disturbance to their existing city charters. Under the proposed law the five councilmen would be elected at large on non-partisan ballots for terms of four years, each subject to recall after six months. Nominations might be made either by petition, or each individual candidate might virtually nominate himself by backing his nomination with a deposit of $50, returnable to him in case he failed to obtain at least 15% as many votes as were cast for any candidate actually elected.

Other particularly interesting features of the Lockport plan are outlined in the following summary taken from the pamphlet named, which also gives some of the arguments in favor of the proposed law:

Double election [is provided for] except for candidates who get a majority at the first election. The alderman receiving the highest vote is chairman and takes the honorary title of mayor, but has no veto power. No other elective officers, except county supervisors. The initiative and referendum are provided for. The council hires a city manager, who in turn appoints all other city employees subject to existing civil service rules. He is responsible to the council for all work of the city, except the schools. He prepares the annual budget, an annual corporate stock budget, sits with the council as its secretary and is responsible for the preparation of its business and the execution of its ordinances and resolutions.

The chief improvement in this act over previous commission plans is the creation of this city manager, thus completing the resemblance of the plan to the private business corporation with its well-demonstrated capacity for efficiency. This gives the highly desirable single-headed executive in place of the five-headed Western system, where each member of the "commission" or council beomes head of a city department. It disposes of the confusion of responsibility inherent in the Western plan where the board as a whole is responsible for all departments and each commission is also responsible for his own. (In Des Moines, for example, a recall was threatened against the commissioner who had charge of the police department. He said he was not to blame for conditions since the other commissioners had, against his will, installed a chief-of-police who defied him!)

This improved plan also frees the people from the necessity of trying to gage the fitness of candidates to do executive and technical work as department heads. The people can elect true representatives, labor men, for example, men who are typical leaders of numerically-important elements of the population and as they will only direct policies and will not personally execute them, the efficiency of the departments is less likely to be interfered with. Likewise the departments will not be subject to demoralization by needless changes of their chief executives, nor will they be at the mercy of the ignorance of some man who is elected on, say, a franchise issue and finds himself obliged to learn and direct the details of city finance or street paving.

The list of available candidates is widened immensely by the fact that the commissioners (aldermen) are not to be obliged to abandon private careers for what may be but a single term of office at the head of an unfamiliar and perhaps uncongenial department. They simply represent the people, at the city hall, with power to review, criticise, question and direct the work of the city manager, who is their creature. Those are conditions which will be attractive to the ablest brains in the community regardless of the small salary.

This plan cannot be criticised as over-concentration of power, since it divides the power much more evenly than the present governments wherein the mayor alone often holds over half of the total power of the city.

The city-manager idea has been in partial use in at least one city for several years past, with apparently satisfactory results. For particulars see Engineering News July 8, 1909, which contained an article entitled "A Municipal Manager at Staunton, Va.," together with brief editorial discussion.

## A New Rattler and Method for the Abrasion Test of Paving Brick.

With the extensive introduction of brick as a paving material, the varying qualities of this material made it desirable to have some definite system of testing brick of various makes. The tests first used included the absorption, transverse strength and crushing strength, and also an abrasion test made in a revolving barrel or rattler. In 1897, the National Brick Manufacturers' Association adopted a standard rattler and test, and this test provided for the use of brick alone in the rattler, without cast-iron blocks or "shot." At the same time, it recommended that the other three tests should be abandoned. In 1900, the association made an important change by specifying the use of "shot," following the practice previously adopted by Prof. A. N. Talbot for testing brick at the University of Illinois.

The rattler machine and test were described in our issues of March 29, 1900, and Jan. 31, 1901.* The rattler was to be 28 ins. diameter and 20 ins. long, the barrel being a 14-sided polygon, with staves of steel plate ¼-in. apart. The speed to be 28 to 30 r. p. m., with not less than 1,800 revolutions for a test. The charge was to consist of 12 paving bricks (or 9 paving blocks), with 300 lbs. of cast-iron shot of two sizes: (1) 2½ ins. square and 4½ ins. long, weighing 7½ lbs. each (75 lbs. for a charge); (2) 1½-in. cubes of an aggregate weight of 225 lbs. This machine and test were adopted also by the American Society for Testing Materials in 1901 (Engineering News, Oct. 10, 1901).

While the standard was as noted above, the specifications permitted certain variations in shape, dimensions, etc., and the introduction of such variations has been considered as vitiating the value of the tests for purposes of comparison. The difficulties have long been recognized. The nature of the stave (whether of cast iron, cast steel or other material) had a considerable effect upon the loss found in the test, and the hardness of the shot also gave divergent results. As a result, some testing laboratories obtained losses of 2 to 4% higher than other laboratories. The matter has been taken up by the National Paving Brick Manufacturers' Association (an organization distinct from the National Brick Manufacturers' Association), and at its annual meeting at Louisville, Ky. (Feb. 7, 1911), a report was presented recommending certain changes in the design of the machine and in the tests. One of the principal changes (besides eliminating the former permissible alternatives) was in specifying spherical "shot" instead of rectangular and cubical blocks. The new machine is thought to offer a form of stave which may be replaced easily, and we are informed that the hardness of the new style of shot appears to be quite uniform.

The report was adopted, and the machine and methods are now the standards of the National Paving Brick Manufacturers' Association. In Figs. 1 and 2 are shown the design of the machine; its cost is estimated at about $150, with $22.50 extra for 500 lbs. of "shot." This design has been accepted by the Organization of City Officials for Standardizing Paving Specifications. Prof. A. N. Talbot (as the representative of the committee for the Society of Municipal Improvements) has investigated the tests made at Indianapolis and Columbus, and has agreed that the new rattler is worth trying. The following is an abstract of the report, and the specifications which accomplished it:

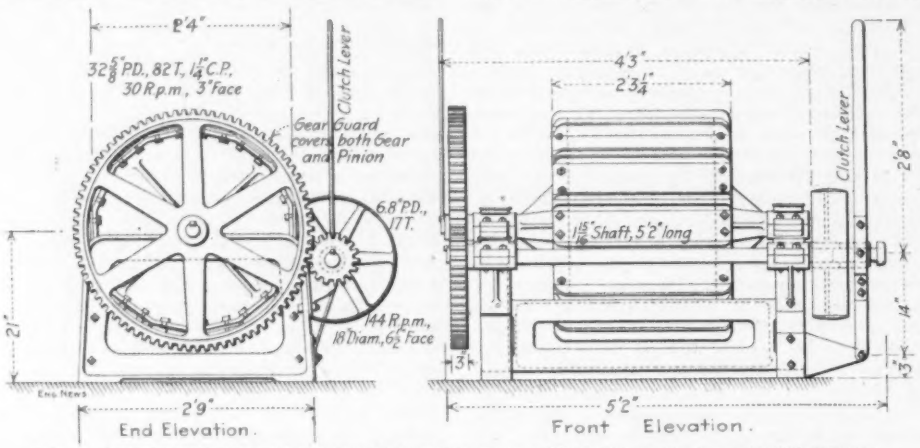


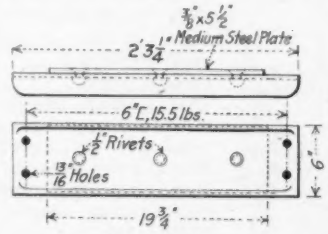

FIG. 1. STANDARD DESIGN OF RATTLER FOR THE ABRASION TEST OF PAVING BRICK.
(Adopted by the National Paving Brick Manufacturers' Association, and by the Organization of City Officials for Standardizing Paving Specifications.)

Practical use of the rattler which was adopted in 1901 by the National Brick Manufacturers' Association developed a great variation in results, due to the fact that the specifications were not definite. This led to a great difference in the construction of the machine, the character of the shot and the manner of conducting the test. From these results a condition was created that was unsatisfactory to both the user and maker of paving brick.

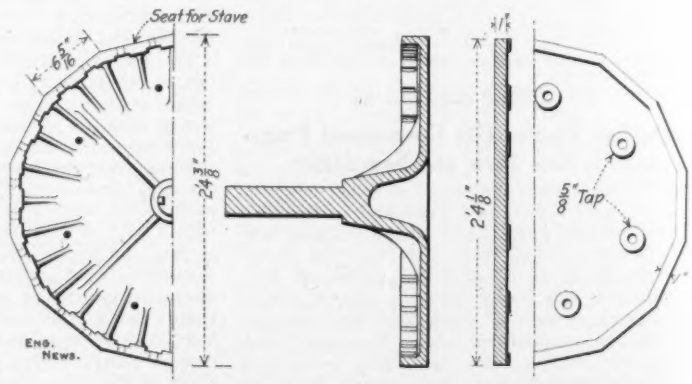
The National Paving Brick Manufacturers' Association felt it so important both to itself and the users of paving brick that it authorized a series of experiments and tests to be made for the purpose of specifying a rattler and test that would avoid the uncertainty and lack of uniformity.* This association appointed a committee to investigate the subject of paving brick tests, and to recommend standard methods for conducting them. The committee procured the services of Prof. Edward Orton (Ohio State University) and Marion W. Blair (Indianapolis), who were to make duplicate tests on machines of given specifications and, if possible, to produce a machine that could be commercially furnished and would produce uniform results.

After due consideration of the construction of and the results obtained by the experimental use of the rattler (described below), it is the conclusion of this committee that the National Paving Brick Manufacturers' Association has completed a machine and specifications (covering its construction and manner of operation) that will produce uniform results, and that the trouble of erratic results as formerly obtained is now practically eliminated.

But this perfected machine can never make the No. 1 paving brick of the different manufacturers, or the material in the different localities where the machine will be used, to test the same. Neither do we believe that it is the duty or object of this association to determine the class of the material that should be used by any city on its several streets (requiring as it were a different grade of material), or to determine for the different localities the class of material that should be used in that locality. But the machine is submitted to the engineers or city officials that they may determine the quality of the material suitable for their use, and to the manufacturer that he may determine the quality of the material of his manufacture, in so far as they may be determined by this method.




Stave.




Trunnion and Head Half Head Liner.

FIG. 2. DETAILS OF RATTLER FOR TESTING PAVING BRICK.

### Specifications for Rattler and Test.

THE BARREL.—The barrel of the machine shall be made up of the heads, head liners and staves. The heads shall be cast with trunnions in one piece. The trunnion bearings shall not be less than 2½ ins. in diameter or 6 ins. long. The heads shall not be less than ⅝-in. nor more than ⅞-in. thick. In outline each head shall be a regular 14-sided polygon inscribed in a circle 28⅝ ins. diameter. The heads shall be provided with [illegible] to afford a means of fastening the staves. The [illegible] shall be slotted on the outer edge to provide for two ⅞-in. bolts at each end of each stave. There shall be for each head a cast-iron head liner 1-in. thick, conforming to the outline of the head, but inscribed in a circle 28⅛ ins. diameter. This liner or wear plate shall be fastened to the head by seven ⅝-in. cap screws. The wear plates, whenever they become worn down ⅛-in. below their initial surface level, at any point of their surface, must be replaced. These plates are to be of what is known as hard machinery iron, and must contain not less than 1% combined carbon. The faces of the polygon must be smooth and give uniform bearing for the staves. To secure the desired uniform bearing the faces of the head may be ground or machined.

The staves shall be made of 6-in. medium steel structural channels 27¼ ins. long and weighing 15.5 lbs. per lin. ft. The channels shall be drilled with 13-16-in. holes for bolts to fasten them to the heads. The space between the staves will be determined by the accuracy of the heads, but must not exceed 5/16-in. The staves when bolted to the heads shall form a barrel 20 ins. long (inside) between the wear plates.

The interior or flat side of each channel must be protected by a ⅜-in. lining or wear plate of medium steel, 5½ × 19¾ ins., riveted to the channel by three ½-in. rivets. The rivet holes shall be countersunk on the face of the wear plate and the rivets shall be driven hot and chipped off flush with the surface of the plate. These plates shall be inspected from time to time, and if found loose shall be at once reriveted, but no wear plate shall be replaced by a new one except as the whole set is changed. No set of wear plates shall be used for more than 150 tests.

DRIVING MECHANISM.—The barrel should be mounted on a cast-iron frame of sufficient strength and rigidity to support it without undue vibration. It should rest on a rigid foundation and be bolted to this at not less than four points.

It should be driven by gearing whose ratio of driver to driven should not be less than 1:4. The countershaft upon which the driving pinion is mounted should not be less than $1^{15}/_{16}$ ins. diameter, with bearings not less than 6 ins. long. The pulley should not be less than 18 ins. diameter and 6½ ins. face. A 6-in. belt of double-strength leather (properly adjusted to avoid unnecessary slipping) should be used.

The National Paving Brick Manufacturers' Association will furnish without cost the complete drawings of a machine which will meet the above specifications and requirements.

ABRASIVE CHARGE.—This shall consist of two sizes of cast-iron spheres. The larger size shall be 3.75 ins. diameter when new and shall weigh (when new) approximately 7.5 lbs. (3.4 kgs.) each. Ten shall be used.

These shall be weighed separately after each ten tests, and when the weight of any large shot falls to 7 lbs. (3.175 kgs.) it shall be discarded and a new one

*A rattler used at Purdue University was illustrated in our issue of Jan. 3, 1901.

*The National Brick Manufacturers' Association (which adopted the specifications in 1901) and the National Paving Brick Manufacturers' Association (which has adopted the present specifications of 1911) are separate and distinct organizations.

substituted; provided, however, that all of the large shot shall not be replaced at any single time, and that so far as possible the large shots shall compose a graduated series in various stages of wear.

The smaller spheres shall be (when new) 1.875 ins. diameter, shall weigh not to exceed 0.95-lb. (0.430 kgs.) each. Of these spheres so many shall be used as will bring the collective weight of the large and small spheres nearly to 300 lbs. No small sphere shall be retained in use after it has been worn so that it will pass a 1.7-in. circular hole drilled in a ¼-in. cast-iron plate, or weigh less than 0.75 lbs. (0.34 kg.). Further, the small spheres shall be tested by passing them over such an iron plate drilled with such holes, or, shall be weighed after every ten tests; and any which pass through or are below specified weight shall be replaced by new spheres. All of the small spheres shall not be rejected and replaced by new ones at any one time, and so far as possible they shall compose a graduated series in various stages of wear. At any time that any sphere is found to be broken or defective it shall be replaced at once.

The iron composing these spheres shall have a chemical composition within the following limits (being the minimum for combined carbon, and the maximum allowable for the others): combined carbon, 2.5%; graphitic carbon, 0.1%; silicon, 1%; manganese, 0.5%; phosphorus, 0.25%; sulphur, 0.08%.

THE BRICK CHARGE.—The number of brick per charge shall be ten for all bricks of the so-called "block size" whose dimensions fall between 8 to 9 ins. in length, 3 to 3¾ ins. in breadth, and 3¾ to 4¼ ins. in thickness. No block should be selected for test that would be rejected by any other requirements of the specifications. The brick shall be clean and dried for at least three hours in a temperature of 100° F.

THE TEST.—The rattler shall be rotated at a uniform rate of not less than 29½ nor more than 30½ r. p. m., and 1,800 revolutions shall constitute the standard test. A margin of not to exceed ten revolutions will be allowed for stopping. Only one start and stop per test is regular and acceptable. A counting machine shall be attached to the rattler for counting the revolutions.

RESULTS.—The loss shall be calculated in percentage of the original weight of the dried brick composing the charge. In weighing the rattled brick any piece weighing less than 1 lb. shall be rejected.

## Annual Meeting of the Engineering Society of Wisconsin.

The third annual meeting of this Society was held at the University of Wisconsin, Madison, Wis., on Jan. 8 to 10. The Society has a membership of about 130, and about 50 members and visitors were registered. There were five regular sessions, and on the second evening a dinner was given at the University Club. On one afternoon, also, there was a visit to the Capitol heating plant, the sewage disposal plant and some manufacturing plants. At the first session the address of welcome was given by Prof. J. G. D. Mack, on behalf of the University, and a short annual address was read by the President, Mr. C. V. Kerch, City Engineer of Janesville.

The subject of road and street paving occupied a very large proportion of the time, including the whole of one session and a considerable part of another. In a paper on "Bituminous Binders in Road Construction," Mr. H. J. Kuelling, pointed out the very contradictory results obtained in different experiments and pointed out also that the various experiments with other methods of road improvement should not be overlooked; these include wood and stone blocks, brick and concrete paving. Treatment to prevent dust may mean the removal of dust, the laying of dust, or a class of construction which will reduce the dust-producing wear of the paving. Attempts to cure the dust nuisance on country roads have in some cases proved failures, owing to the purchase of oils or compositions without any investigation as to their suitability for the work; this is specially the case where the matter is undertaken by local authorities or others without any engineering aid. Binders which are simply to lay the dust must be of thin consistency; heavier compositions are required when it is desired to improve the condition of the road paving. Such materials were put in two classes: (1) natural bitumens or asphaltic materials, (2) artificial bitumens or tars. The use of such methods in road construction and improvement was held to be still very much in the experimental stage.

Of the same general character was the paper by Mr. L. Kirschbraun (City Asphalt Chemist of Chicago) on "Asphalt and Bituminous Products Used as Macadam Binders." He stated that unless these binders have a real binding value the road is little better than if made simply with water. The penetration method, that is, applying the binder to a finished road, had many difficulties in producing permanent results under trying conditions. Much better results were obtained by the mechanical mixing of the road material with the bituminous binder before the material was laid. The paper discussed the properties of natural asphaltic cements and asphaltic cements produced by the treatment of heavy oil residuum. It referred to the work done by the South Park Commission, Chicago (described in Engineering News, Oct. 21, 1909, p. 434), and stated that the portable plant there used enabled the laying of 640 to 770 sq. yds. per day. Dust preventatives should not be expected to act as a binder, but they may suffice where the traffic is relatively light and the cost of asphaltic-macadam is not warranted. In the discussion, Mr. Kerch (Janesville) referred to the necessity of cooperation between engineers and the manufacturers of paving materials. Mr. Kirschbraun also presented further information in regard to the properties of oils or asphalts suitable for paving, and tests for determining their suitability. Mr. E. E. R. Tratman (Associate Editor of Engineering News) thought that the use of compositions as binders and dust preventatives on existing roads is likely to be regarded with disfavor as the result of improper application. In some cases the material is sold in country towns, and is spread heavily on the streets without even sweeping off the dead leaves, manure or dust. The oil or tar cannot properly penetrate the macadam or gravel paving and a greasy scum remains on the surface. This is spattered over vehicles and clothing and also tramped into the houses. On country roads, the composition is sometimes spread on a rough and dirty surface, and forms pools in ruts and holes. Under such conditions the treatment becomes a nuisance and is likely to cause a prejudice which is not deserved.

A paper on "Progress in Wood Block Paving in the United States" was presented by Mr. Carlisle P. Winslow, of the Forest Products Laboratory. Prof. L. S. Smith presented the report of the Committee on Roads and Pavements, in which he touched upon various systems of construction. In regard to brick paving, he referred to the modified form of rattler machine and rattler test for determining the quality of brick. Brick paving is developing for both streets and highways. In stone block paving, some Eastern cities have introduced blocks of smaller size cut to a smoother finish and laid with closer joints than has been ordinary practice. Such paving (with cement grouted joints) has very much the appearance of brick, and in New York it is favored by automobiles. At first a ⅜-in. joint was specified, but the contractors made so much objection to the difficulty and slow work of paving in this way that a ½-in. joint is now permitted. As to asphaltic-macadam, he considered that the bitulithic paving should not have been patented, and was only patentable through our peculiar patent laws. Practically identical paving had been used ten years before. He considered that a desirable improvement would be in developing something between asphalt-macadam and street asphalt.

Another paper closely related to the subject of street paving was that by Mr. F. G. Simmons on "The Use of T Rails in Street Railway Construction." Mr. Simmons (who is Chief Engineer of the Milwaukee electric-railway system) favors the use of T rails in preference to grooved rails on tram-head rails for paved streets using either ordinary railway sections or the high T-girder rails according to conditions. Streets having railway tracks should have, in his opinion, block pavement of some kind (stone, brick or wood); sheet asphalt should be used only on streets having no tracks. To lay a line of blocks between the rail and asphalt paving does not remedy the objections to asphalt. To form a flangeway for car wheels he advocated the plan used in Milwaukee, the paving between the rails being crowned from below the rail head at each side to a level with the top of the rail at the center. Narrower flangeways formed by nose bricks or blocks are liable to become wider and irregular by wear of the edge of the brick or block. The height of the rail head (at Milwaukee) is 1 in., and vehicles with wheels inside the rail have to climb this. But with a vehicle crossing the track the rise from the point at which the wheel rests on the paving is only ⅜-in. An objection to the arrangement is that it breaks up the desirable smooth contour of the street very much more than the use of a regular groove. Mr. Kerch said that at Janesville, Wis., the T-girder rail and narrow flangeways formed with nose blocks give very good results.

This society pays more attention to mechanical engineering than most of the state engineering societies, and papers on this class of subjects occupied one session. Mr. Henry C. Schneider dealt with "The Theory and Development of Windmills;" he included (1) the horizontal wheel (or air turbine) in which is surrounded by angular fixed vanes to direct the wind upon the radial blades of the wheel, (2) the old-fashioned slow-moving large vertical wheel with few blades, and (3) the modern high-speed vertical wheel with numerous blades. In the discussion it was remarked that engineers in country districts are often asked how windmill power can be applied for power purposes, electric lighting, etc. Mr. C. J. Atkinson, in a paper on "The Power Plant of the Northern Glass Works, Milwaukee," described a gas-producer plant which has reduced the coal consumption to 33% of that of the former steam plant. Mr. J. C. White discussed the method of preparing coal on the B. T. U. heat-unit basis, and the discussion showed a necessity and desire for uniformity in specifications for coal. It was voted to refer this particular subject to the Committee on Mechanical Engineering for consideration.

Mr. A. L. Goddard (Superintendent of Shops at the University) presented a paper on "High-Speed Steel for Cutting Tools." A paper by H. B. Sanford and C. R. Higson presented some "Experimental Data on the Use of Fans on Dynamometers." A pulley on a motor-driven shaft had bolted against one face a long arm to which were attached two rectangular iron plates forming fan blades. The experiments were made with plates of different sizes and at different distances upon the arm. The HP. required for the 9 × 8-in. plates at different speeds and radii may be summarized approximately as follows:

| Speed, r. p. m. | Radius 20½ ins. | Radius 17½ ins. | Radius 14½ ins. |
|---|---|---|---|
| 700 | 5 | 3 | 2 |
| 800 | 7 | 5 | 4 |
| 1,000 | 15 | 9 | 5 |
| 1,100 | 21 | 12 | 7 |

Two matters of legislation were discussed, one was in regard to a bill by which the structural engineer or designer of a building would be made subordinate to the architect. This was considered to be very objectionable, as likely to affect the strength or safety of buildings, and a committee was appointed to look into the matter. The other subject was the proposition to combine the offices of County Surveyor and County Highway Engineer. A paper on "Reinforced Concrete Bridges" was read by Mr. D. B. Luten (Indianapolis) and was illustrated by numerous views of girder and arch bridges and arch viaducts. By means of a model, also, he showed the advantages of system of arch reinforcing in which the longitudinal bars are bent so as to lie near the extrados at the sides and near the intrados at the crown. In the discussion Mr. Kerch referred to the fact that many bridge companies work to specifications of their own. He recently prepared plans and very complete and rigid specifications for some bridge work. The bids ranged from $13,000 to $24,000, and none of them complied with all the requirements of the specifications. Mr. Arthur Peabody (University Architect), in a paper on "Field Work in Concrete Floor Construction at the University," described a slab-and-girder special design used in a manufacturing plant; each group of stirrups in the girder was formed of a single bar so bent as to form two parallel vertical legs connected by a top transverse section while a bottom longitudinal portion extends to the next leg.

Among other papers presented were the following: "The Supplies," by W. C. Lounsbury (re-

ferring to the use of sulphate of copper and hypochlorite of lime); "Relation of Storage Reservoirs to Stream Flow on the Wisconsin River," by Clinton B. Stewart; and "The Forest Products Laboratory," by McGarvey Cline.

The election of officers resulted as follows: President, F. G. Simmons (Engineer of Way, Milwaukee Electric Railway & Light Co.), Milwaukee, Wis.; Vice-President, P. H. Connolly, Racine, Wis.

## A Federal Suit Against Thirty-Five Incandescent Electric Lamp Concerns.

On March 3, the U. S. Attorney General, G. W. Wickersham, brought suit in the U. S. Circuit Court at Cleveland, Ohio, against 35 manufacturing concerns on the charge of making unlawful contracts, combinations and conspiracies in restraint of interstate trade in incandescent electric lamps. The companies concerned manufacture practically all the electric incandescent lamps made in this country. The leading ones involved are the General Electric Co., the Westinghouse Electric and Manufacturing Co., the Westinghouse Lamp Co., and the National Electric Lamp Co. The latter concern is a holding company through which the more prominent "independent" makers are controlled by the General Electric Co., which, it is charged, owns 75.2% of the National stock. The controlled companies are:

The American Incandescent Lamp Co., of New York; the Bonner Electric Co., of Youngstown, Ohio; the Brilliant Electric Co., of Cleveland, Ohio; the Bryan-Marsh Co., of Chicago; the Buckeye Electric Co., of Cleveland; the Colonial Electric Co., of Warren, Ohio; the Columbia Incandescent Lamp Co., of St. Louis; the Economy Electric Co., of Warren, Ohio; the Fostoria Incandescent Lamp Co., of Fostoria, Ohio; the Franklin Electric Manufacturing Co., of Hartford, Conn.; the General Incandescent Lamp Co., of Cleveland; the Independent Incandescent Lamp Co. (not in recent business directories); the Liberty Electric Manufacturing Co., of Pittsburg; the Munder Electric Co., of Springfield, Mass.; the New York & Ohio Co., of Warren, Ohio; the Shelby Electric Co., of Shelby, Ohio; the Standard Electric Manufacturing Co., of Warren, Ohio; the Sterling Electric Manufacturing Co. of Warren, Ohio; the Sunbeam Incandescent Lamp Co., of New York City, and the Warren Electric & Specialty Co., of Warren, Ohio. These constitute, for the most part, also the National Electric Lamp Association, which has received considerable publicity as a cooperative association which maintained an engineering department for perfecting lamp processes among other things.

The following companies not directly engaged in the manufacture of incandescent lamps are named in the suit:

The York Electric Machine Co., of York, Pa.; Elmer F. Dwyer, doing business as the Dwyer Machine Co., of Lynn, Mass. (makers of incandescent-lamp machinery); the Fostoria Bulb & Bottle Co., of Fostoria, Ohio; the Libbey Glass Co., of Toledo; the Corning Glass Works, of Corning, N. Y.; the Phoenix Glass Co., of New York City (makers of glass tubes and bulbs), and the Providence Gas Burner Co., of Providence, R. I. (maker of lamp bases).

In addition to the concerns held through the National Lamp Co., five independent makers are named in the suit as entering into agreements to maintain prices. These are the Westinghouse Electric & Manufacturing Co. and the Westinghouse Lamp Co., the Aetna Electric Co. of New York City, the Capital Electric Co. of Denver, Col., the Kentucky Electrical Co. of Owensboro, Ky., and the Gilmore Electric Co., of Boston.

The charges relate that the concerns named control the manufacturing and sale of over 97% of all the incandescent electric lamps made in this country. This total annual production is stated approximately as 80,000,000 lamps, valued at $18,000,000. Some 60% of the production is in carbon-filament types.

The Attorney General's petition reviews the history of the "Incandescent Lamp Manufacturers" from 1896. This unincorporated association appears from the charges to have been a combination of the General Electric, Bryan-Marsh, Buckeye, Columbia and Sunbeam companies, with the Adams-Bagnall Electric Co. and the Perkens Electric Switch Manufacturing Co. The latter two are not now making incandescent lamps. It is alleged that the combination was in violation of the Act of July 2, 1890, as its objects were to fix prices, to allot business and to regulate the sale of standard lamps for domestic use. The agreement is claimed to have been made for three years and to have been renewed at times up to January, 1901, with the New York and Ohio, Shelby, Fostoria, Colonial, General Incandescent, Munder and Warren companies included. There was also included the Davis Electrical Works, Aylesworth & Jackson, and the Bernstein Electric Co., which soon retired from the lamp business with the Adams-Bagnall and Perkins Switch companies. From time to time, it is alleged, agreements were made with the Westinghouse companies to maintain prices.

Charges are made that, in January, 1901, the leading members of the old association decided to make the combination permanent and to crush all competition in the business. To that end, the National Electric Lamp Co. was incorporated May 3, 1901, to include all the agreeing concerns except the General Electric and Westinghouse companies. The capital consisted of $500,000 common stock, $150,000 preferred stock, and an authorized issue of $2,000,000 in bonds. The stock, bonds and notes of the National company were variously distributed in exchange for stocks of the subsidiary companies and for cash. The General Electric Co. secured $360,000 in stock for $120,000 cash and later, from time to time, advanced cash in exchange for bonds as money was needed over that contributed by the absorbed companies. In 1908 the $150,000 preferred stock was retired and the common stock was increased at different times to $5,000,000; of this increase $4,000,000 was distributed in stock dividends to the old stockholders. Cash dividends have been paid amounting to $710,000 since 1903, and there is remaining an undivided profit of $1,439,159.

It is alleged that the General Electric Co. owns 75.2% of the stock of the National Co.; the remaining 24.8% is owned by Messrs. B. G. and H. A. Tremaine, J. B. and J. R. Crouse, and F. S. Terry, all officers of the National Co., but the General Electric Co. holds an option on this stock also. None of the holdings of the General Electric Co., the petition states, have been in its own name and an appearance of independence has been kept by the National company.

It is claimed that unfair competition has been practiced in selling inferior lamps at reduced prices to customers of truly independent makers, and in organizing concerns which were mere selling agents to undersell at any prices necessary to deprive the independent makers of business. It is charged that the contracts of the National company with the York and Dwyer concerns are unlawful as the latter were required to refrain from making lamp machinery for sale to other than approved concerns. It is charged that the General Electric, National and controlled companies have entered into unfair contracts with the Corning, Fostoria, Libbey, Phoenix and Providence companies whereby the defendants have agreed to purchase all of certain classes of materials from these concerns which in turn have agreed to sell to truly independent makers only at excessive prices. These producers control the production of such materials.

The petition charges that the General Electric and National companies have unlawfully acquired patents, applications and inventions, covering the manufacture of tantalum and tungsten-filament lamps, for suppressing all competition in interstate trade in these lamps. It is recited that, in 1906, these two companies paid the Siemens & Halske company, of Germany, $250,000 for the right to manufacture tantalum-filament lamps. All filaments were to be purchased from Siemens & Halske and a share of the profits from American sales also was to go to the latter firm. The General Electric Co. supplied 60% of the payment and the National company 40%.

The petition states that the General Electric Co. in 1906 secured an option on the exclusive American rights for the tungsten processes of the Auer Gesellshaft, of Berlin, Germany (the Welsbach company), the consideration being $100,000 plus a certain royalty. A 40% interest in the option was sold to the National company. In April, 1909, the General Electric Co. paid $170,000 to Mr. Sigmund Bergman and the Bergman Electricity Works, of Berlin, Germany, for American rights on their patent applications and inventions of processes, machinery, lamps and filaments of whatever character. The agreement was made that the Bergman interests would stop selling and delivering lamps in this country. The National company purchased a 40% undivided interest in these rights. It is also [illegible] that in 1909 the General Electric Co. paid $2[illegible] for the Just and Hanaman tungsten-lamp [illegible] and $240,000 for the Kuzel rights.

Relief is sought by the Attorney Gen[illegible] in several ways, briefly abstracted as follows:

(1) The court is asked to restrain the defendants [illegible] from doing any act in pursuance of or for the purpose [illegible] straining the trade and commerce in incandescent [illegible]

(2) The court is asked to restrain the National [illegible]tric Lamp Co. from voting the stock of, or receiving [illegible] dividends from the various companies and corpo[illegible] unlawfully acquired and controlled and from exe[illegible] any control whatsoever over them.

(3) It is asked that the issuing companies be [illegible]ed from paying or permitting to be paid to the [illegible]nal Electric Lamp Co., any dividends upon stock un[illegible]ly acquired.

(4) It is asked that the General Electric Co. [illegible] enjoined from further using or exercising the rights and powers incident to unlawfully acquired shares, to bring concert and cooperation between the National [illegible]tric Lamp Co. and the other defendants or to obstruct trade and commerce in incandescent electric lamps or to aid in the preservation of or attempt to secure a monopoly.

(5) It is prayed that the parties to the agreements, combinations and conspiracies be enjoined perpetually from engaging therein and from any like or similar agreements, combinations and conspiracies.

(6) It is asked that the defendants be restrained from exercising control over patents, applications and inventions, acquired for the purpose of suppressing all competition in the sale of lamps, or for using the same to obstruct trade and commerce in incandescent electric lamps or so as to aid in the preservation of or attempt to secure a monopoly.

(7) It is asked that the General Electric, National and controlled companies be restrained from enforcing the provisions of contracts made with dealers and jobbers who are compelled to agree to buy all of their carbon-filament lamps from defendants and from making any like or similar contracts.

(8) It is prayed that these defendants be restrained and forbidden from enforcing the provisions of contracts with the York, Dwyer, Corning, Fostoria, Libbey, Phoenix and Providence companies, to obstruct trade or to preserve or attempt to secure a monopoly.

No authoritative statement of the attitude of the several companies involved has been made up to the present time. It is intimated, however, that the suit will define patent rights rather than relieve any alleged unlawful commercial and economic condition. It is possible that the defense will be made that all the tungsten patents have been acquired to develop the best possible type of lamp rather than to keep up prices. It will probably be claimed that the owner of a patent has the right to establish the minimum price at which the patented product shall be sold.

## Collapse of a Long-Span Tile-and-Concrete Floor.

A concrete-and-tile floor under construction in an apartment house building at No. 10-14 East 87th St., New York City, collapsed on March 9, 1911, and caused the death of the four workmen who were carried down with it. The building is of the usual steel skeleton construction, eight stories and basement, with the larger portion of its floor slabs of the short-span, wire-mesh reinforced-concrete type, but for some reason, not at present obtainable, the architects desired to have five of the floor panels in spans too great for the ordinary floor and, for these five panels, had called for the tile-and-concrete floor construction controlled by the Building Improvement Co., of New York City, and known as the Burchartz System. This system was described in Engineering News, June 16, 1910, p. 708. It consists of a series of hat-shaped tile block so formed and so arranged across the span as to allow of a crossed system of reinforced-concrete beams formed by pouring concrete between and on top of the block. On account of this two-way reinforcement, it is claimed to be especially adaptable for long spans. Five of the panels in the building were of this type for each of the floors from the second to the eighth and for the roof. The first floor, over the basement and at the street level, on which all the hauling incidental to erection was done, was of the regular short-span type for the entire floor area. It was one of the long-span panels that failed.

No official inquiry into the accident has as yet

been held, so the details of construction, which in this case are very necessary in the study of the cause of the collapse, are not available. The wreckage of building itself offers very little help in this matter and the extemporaneous statements of those connected with the work are more confusing than is usual in such cases, so until the coroner's inquest calls forth sworn testimony, an account of the accident must be very incomplete. An inspection of the building and interviews with several men connected with the work, however, have developed the following facts.

Practically all of the steel work and most of the short-span floor slabs had been completed. Three of the five long-span panels, all 24 ft. 5 ins. in one direction and varying from 14 to 18 ft. in the other, had been completed about March 1 and are still supported by struts in all but the first, or working, floor, where, on March 10, the struts were out and, so far as could be learned, had been out for some time. About March 1, possibly a few days earlier but certainly no earlier than Feb. 24, the erection of the fourth panel, 18 ft. 4½ ins. by 25 ft. 9 ins. in area, was started from the second floor and carried up floor by floor, at the rate of about two days per floor, until on March 9 concreting was being carried on at the roof. Just what floors were supported by struts is not known, though the existence of struts in the older sections of the floor and in the wreckage would indicate that they were present at least on some of the floors of the newest section. A hoisting-engine was in the middle of the first floor of this panel (older concrete, with the wire-mesh reinforced short slabs) so that it is very probable that the requirements of space for this engine and for the movements of workmen may have led to the early removal of the forms there. The fifth and last long-span panel has not been started.

At 5.20 p. m. on March 9, after most of the workmen had left the building, this fourth section collapsed, and carried down the four workmen on it to their death. The collapse is complete through the panel from roof to cellar, and the point of initial failure cannot be told from the wreckage. The concrete throughout the whole eight floors is very poor (there was a mixer on the job but it was used only occasionally), but is much harder and better as the older concrete of the lower floors is reached. That on the top three or four floors, which must have been at least five days old at the time of the accident was so weak the day after the collapse as to crumble under the slight pressure of the fingers. The temperature during laying was not excessively low, nor does the concrete present the appearance of having been frozen. From the meager evidence of rods clinging to the supporting beams it would seem that the reinforcement was not placed to the extent called for in the design, which had been approved by the Building Department of the city. Finally, the work was being done with very low class labor, under probably no efficient inspection.

Considering the quality of the concrete found on the various floors, the collapse could have been caused by the removal of struts from under any of the floors from the first up, thus throwing the weight of all the floors above upon the one thus relieved.

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A FLYWHEEL BURST at the Bromwell wire factory at Greensburg, Ind., March 2. The accident is ascribed to the breaking of the governor belt. The damage to property is estimated at $1,500.

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THREE ROCK DRILLERS WERE KILLED March 3 at the plant of the Ontario Power Co., at Niagara Falls, Ont., by an explosion which occurred while the men were at work in the penstock. The accident is ascribed to the leakage into the penstock of natural gas from a nearby gas main.

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A BOILER EXPLOSION in the logging yard of the Portland Ry., Light & Power Co., at Estacada, Ore., March 4, killed five men and fatally injured two others. The boiler was one used in connection with a donkey engine for hauling logs. Reports state that at the time of the accident there was no safety valve on the boiler.

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A MINE CAVE-IN at the Norman open-pit iron mine at Virginia, Minn., March 11, buried 18 or 20 men, none of whom have been rescued alive. The cave-in is ascribed to the loosening of the soil by thaws.

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A POWDER MILL EXPLOSION at Pleasant Prairie, Wis., on the evening of March 9 destroyed most of the buildings of the Du Pont de Nemours power mill and wrecked, according to press reports, practically all the buildings in Pleasant Prairie, a town of a few hundred inhabitants. The concussion caused by the explosion was manifested at Chicago, some 65 miles away, in the breaking of numerous windows. Only one person is known to have been killed. Reports state that the explosion involved more than 150 tons of dynamite, besides several thousand kegs of giant powder.

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A FIRE AT THE TELEPHONE EXCHANGE of the Home Telephone Co., at Los Angeles, Cal., on March 4, disabled 7,000 subscribers' telephones.

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AN EARTH SLIDE NEAR THE GATUN LOCKS on March 10 is reported in recent press dispatches. It is said to have taken place just north of the locks, and to have involved a volume of several hundred thousand cubic yards. Several workmen were killed.

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A BILL TO CHANGE THE NAME of the Public Health and Marine-Hospital Service to the much shorter and handier title Public Health Service and to give the Service additional powers and increase the salaries of the officers of the Service passed the House of Representatives at the session of Congress just adjourned but failed to pass the Senate. The increase of powers provided for in the bill was embodied in the following words:

> The Public Health Service may study and investigate the diseases of man and conditions influencing the propagation and spread thereof, including sanitation and sewage and the pollution either directly or indirectly of the navigable streams and lakes of the United States, and it may from time to time issue information in the form of publications for the use of the public.

Had the bill been enacted, the salaries of the Surgeon General would have been increased to $6,000; the Assistant Surgeon General, to $4,000; the senior surgeons, of which there would have been ten, to $3,500; Surgeon, to $3,000; passed Assistant Surgeon, to $2,400, and Assistant Surgeon, to $2,000. Provision was also made for increases in these salaries for each five years' service.

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PLENTY OF WATER FOR VARIOUS IRRIGATION projects of the U. S. Reclamation Service during the coming season is expected as a result of recent heavy snowfalls at the headwaters of some of the streams. The engineer in charge of the Truckee-Carson Project reports that the snowfall depths for this period of the winter season exceed all previous records. Besides other encouraging reports of the same general character, word has been received recently from Phoenix, Ariz., to the effect that the water behind the Roosevelt Dam in the second week of March was 157 ft. in depth, and still rising. This increasingly large sheet of water, it is stated, will add materially to the impressiveness of the scene at the formal dedication of the dam by Colonel Roosevelt on March 18.

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BOILER, ELEVATOR AND FLYWHEEL ACCIDENTS in the United States and Canada, as listed by the Fidelity & Casualty Co., of New York, caused the death of 58 persons during December, 1910. The number of boiler explosions in the month was 39, in which more than 31 persons were killed. The list of explosions includes eight boilers used for steam or hot-water heating, none of which, however, caused any fatalities. The loss of life from exploding boilers would have been much below the usual monthly figure except for the exceptionally disastrous accident at Pittsfield, Mass., Dec. 29, in which 17 persons were killed. This accident was noted in Eng. News, Jan. 5.

The elevator accidents during the month numbered 81 and killed 24 persons. Of those killed, 9 were crushed between car and shaft, 8 fell down shafts and 7 lost their lives through the fall of cars.

The six flywheel accidents of the month caused three deaths. This includes four emery wheel accidents, one of which was the cause of one death.

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## Personals.

Mr. Frank Campbell has been appointed Town Engineer of Hackensack, N. J., by the Hackensack Improvement Commission.

Mr. Ernest Stenger, formerly with the Denver & Rio Grande Ry, has been appointed General Manager of the St. Joseph & Grand Island R. R.

Mr. C. L. Bardo, formerly Superintendent of the New York Central R. R. Electric Division, has been appointed Assistant General Manager of the Lehigh Valley R. R.

Mr. Joseph H. Gumbes, Division Engineer of the Pittsburg Division of the Pennsylvania R. R., has been promoted to Assistant Superintendent of the same division, succeeding Mr. D. C. Stewart, promoted.

Mr. Theodore B. Ford, M. Am. Soc. C. E., of the firm of Scofield & Ford, Civil Engineers, of Bridgeport, Conn., has been appointed a member of the Connecticut State Railroad Commission, succeeding the late William O. Seymour.

Mr. G. B. Herington, Division Engineer of the Sacramento Division of the Southern Pacific Ry., has resigned to become Superintendent of Construction of the Mountain Quarries Co. R. R. with headquarters at Auburn, Cal.

Mr. Lewis E. Ashbaugh, M. Am. Soc. C. E., Hydraulic Engineer with J. G. White & Co., and formerly connected with their Seattle, Wash., office, has been transferred to the London, England, office of the same company in order to handle its hydro-electric work in Brazil.

Mr. D. K. Colburn, formerly Bridge Engineer of the Galveston, Harrisburg & San Antonio Ry. and the Louisiana Western Ry. at Houston, Tex., has been promoted to Engineer of Maintenance-of-Way, succeeding the late A. V. Kellogg, whose death was noted in our issue of Feb. 23.

Mr. John G. Bowman, Secretary of the Carnegie Foundation, has been elected President of Iowa State University. Mr. Bowman is but 33 years old and is said to be the youngest college president of the country. He graduated from Iowa State University in 1899 and received his M. A. degree there in 1904.

Mr. Robert V. Massey, formerly Division Engineer of the New York Division of the Pennsylvania R. R., has been appointed Superintendent of the New York, Philadelphia & Norfolk R. R. with headquarters at Cape Charles, Va., succeeding Mr. Elisha Lee, whose promotion was noted in our columns on March 9.

Mr. Charles L. B. Anderson, Assoc. M. Am. Soc. C. E., has retired from the firm of Hazlehurst & Anderson, Consulting Engineers, of Atlanta, Ga, and Wilmington, N. C., to become Chief Engineer of the Clarendon Construction Co., of Wilmington. Mr. James N. Hazlehurst, M. Am. Soc. C. E., will continue his practice at Atlanta.

Mr. Lloyd T. Emory, Jun. Am. Soc. C. E., formerly General Superintendent of the Kaolin Mining Co., of Philadelphia, Pa., and Mr. R. H. Eisenbrey, formerly of the Harrison Safety Boiler Works, of Philadelphia, have formed the firm of Emory & Eisenbrey for the practice of a general engineering business with offices in the Harrison Bldg., Philadelphia.

Prof. M. C. Whitaker, of the Department of Industrial Chemistry of Columbia University, and formerly Superintendent of the Welsbach Co.'s works at Gloucester, N. J., has been appointed Editor of the "Journal of Industrial and Engineering Chemistry." Professor W. D. Richardson, of Chicago, Ill., has retired as Editor because of the pressure of other work, but will continue as one of several associate editors.

Mr. Frederick L. Ford, M. Am. Soc. C. E., City Engineer of Hartford, Conn., will resign his position with the city on April 1, to become a member of the engineering firm of Ford, Buck & Sheldon, of Hartford. He went to Hartford in 1898 as Assistant City Engineer and has been City Engineer since 1902. He has been President of the Connecticut Society of Civil Engineers and prominent in the work of the American Civic Association and the National Conference on City Planning.

Mr. R. S. Stockton, Assoc. M. Am. Soc. C. E., Project Engineer of the Lower Yellowstone Irrigation Project of the United States Reclamation Service, has resigned. He will become Engineer in charge of operation and maintenance of the Canadian Pacific Ry. Co.'s irrigation operations in Alberta, Canada. Mr. Stockton is a graduate of the Colorado School of Mines and has had a varied experience in government and hydraulic development work. From 1895 to 1903 he was Professor of Mathematics at the Colorado School of Mines. Since that time he has been with the Reclamation Service. Mr. L. H. Mitchell, Assoc. M. Am. Soc. C. E., has been appointed Acting Project Engineer to succeed Mr. Stockton.

The President has made the following appointments in the new Bureau of Locomotive Boiler Inspection: Chief, Mr. John P. Ensign, of Denver, Colo., for many years a locomotive engineer on the Denver & Rio Grande Ry., and recently Safety Appliance Inspector under the Interstate Commerce Commission; Assistant Chief, Mr. Frank McManamy, of Portland, Ore., a former locomotive engineer and recently Safety Appliance Inspector under the Interstate Commerce Commission, and Assistant Chief, Mr. Garland P. Robinson, of New York City, a graduate of De Pauw University and Chief Inspector under the New York State locomotive boiler inspection laws.

The Pennsylvania R. R. announces the following promotions: Mr. C. H. Niemeyer, formerly Division Engineer of the Conemaugh Division, becomes Division Engineer of the Pittsburg Division; Mr. F. W. Smith, Jr., formerly Supervisor of the Philadelphia Terminal Division, becomes Division Engineer of the Conemaugh Division; Mr. C. I. Leiper, formerly Division Engineer of the Pennsylvania Tunnel & Terminal R. R., becomes Division Engineer of the New York Division; Mr. J. H.

Harris, formerly Division Engineer of the Delaware Division, becomes Division Engineer of the New York Terminal Division; Mr. W. F. Greene, formerly Division Engineer of the Philadelphia Terminal Division, becomes Division Engineer of the Delaware Division; Mr. W. T. Covert, formerly Division Engineer of the Williamsport Division, becomes Division Engineer of the Philadelphia Terminal Division; Mr. C. R. Sinnickson, formerly Supervisor of Division No. 2, Philadelphia Division, becomes Division Engineer of the Williamsport & Susquehanna Division; Mr. S. E. Holland, formerly Supervisor of the Cresson Division, becomes Supervisor of the Philadelphia Terminal Division; Mr. R. R. Nace, formerly Assistant Supervisor of the Maryland Division, becomes Supervisor of the Cresson Division; Mr. J. Schimmel, Jr., formerly Supervisor of the Schuylkill Division, becomes Supervisor of Division No. 2, Philadelphia Division; Mr. D. C. Baird, formerly Assistant Supervisor of the Pittsburg Division, becomes Supervisor of the Schuylkill Division; Mr. M. J. Jones, formerly Assistant Supervisor of the Bellwood Division, becomes Assistant Supervisor of the Pittsburg Division; Mr. N. D. Vernon, formerly Assistant Supervisor of the Monongahela Division, becomes Assistant Supervisor of the Maryland Division.

## Obituary.

C. M. Case, Assistant Engineer of the St. Louis & San Francisco R. R., at Fort Worth, Tex., died on March 4. He was formerly Chief Engineer of the Chicago, Rock Island & Gulf Ry.

Franklin J. Sawtelle, a prominent architect, of Providence, R. I., died at his home in that city from pneumonia on March 9. He had been twice President of the Rhode Island Chapter of the American Institute of Architects.

J. W. Maxwell, General Superintendent of the St. Louis Southwestern Ry., died on March 7. He was born on Oct. 18, 1851, at Urichsville, Ohio. He had served in many capacities in the operating departments of western railways from telegraph operator and trainmaster to superintendent.

Robert Wallace, one of the founders of the American Shipbuilding Co., of Cleveland, Ohio, died in St. Petersburg, Fla., on March 7. He was 76 years old and a native of Ireland. He came to Cleveland when about 20 years of age and was one of the founders of the Globe Iron Works.

James D. Warner, a noted mathematician and one time engineer, died at his home in Brooklyn, N. Y., on March 12. He was born at Half Moon, N. Y., 84 years ago. He graduated from the State Normal School at Albany and received an A. M. degree from Colgate University in 1881. He was at one time with the engineering department of the Kansas Pacific R. R., and for 30 years was a practicing mechanical engineer of New York and Washington, D. C.

## Engineering Societies.

COMING MEETINGS.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 21-23. Annual convention at Chicago, Ill. Secy., E. H. Fritch, 902 Monadnock Block, Chicago, Ill.

AMERICAN ELECTROCHEMICAL SOCIETY.
April 6-8. Annual meeting at New York City. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
May 15-18. Annual meeting at Chattanooga, Tenn. Secy., D. B. Sebastian, 721 La Salle Station, Chicago, Ill.

AMERICAN RAILWAY ASSOCIATION.
May 17. Semi-annual meeting at New York City. Secy., W. F. Allen, 24 Park Pl., New York City.

OHIO SOCIETY OF MECHANICAL, STEAM AND ELECTRICAL ENGINEERS.
May 18-19. Annual convention at Youngstown, Ohio. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 23-25. Annual meeting at New York City. Secy., F. H. Wentworth, 87 Milk St., Boston, Mass.

AIR BRAKE ASSOCIATION.
May 23-26. Annual convention at Chicago, Ill. Secy., F. M. Nellis, 53 State St., Boston, Mass.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 23-26. Annual convention at Pittsburg, Pa. Secy., Richard Moldenke, Watchung, N. J.

INTERNATIONAL MASTER BOILERMAKERS' ASSOCIATION.
May 23-26. Annual convention at Omaha, Neb. Secy., H. D. Vought, 62 Liberty St., New York City.

ENGINEERS' CLUB OF ST. LOUIS.—A paper entitled "The Latest Developments in the Illinois Oil Field" was presented at the meeting of March 15 by Mr. H. A. Wheeler.

NEW YORK ELECTRICAL SOCIETY.—Life membership has been introduced with a fee of $25. The number of life memberships is limited to 100.

CENTRAL RAILWAY CLUB.—At the regular meeting at Buffalo, N. Y., March 10, Mr. John P. Kelly presented a paper on "The Influence of Gravity on Trains Descending Grades, and the Brake Power necessary for Safe Control."

AMERICAN CHEMICAL SOCIETY.—At the March meeting of the Cleveland branch, Mr. W. R. Hulbert lectured on "The Thermit Welding Process." In addition to a general description of the process, he gave a demonstration of its use in repair work and pipe welding.

INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.—The eighth congress will be held at Washington, D. C., and at New York City in September, 1912. An open meeting at Washington, Sept. 4, 1912, will be followed by business and scientific meetings at New York, Sept. 6-13. The secretary is Mr. Bernhard C. Hesse, 25 Broad St., New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The Directors have announced the following nominations as the result of preliminary ballot of the membership: For President, Mr. Gano Dunn, Chief Engineer of the Crocker-Wheeler Co., Ampere, N. J., and Mr. Ralph D. Mershon, Consulting Engineer, New York City; for Vice-Presidents, Mr. D. B. Rushmore, of Schenectady; Mr. C. W. Stone, of Schenectady, and Mr. W. G. Carleton, of the New York Central & Hudson River R. R., New York City; for Managers, Mr. F. S. Hunting, of Fort Wayne, Ind.; Mr. Farley Osgood, of Newark, N. J.; Mr. N. W. Storer, of Pittsburg, and Mr. W. S. Lee, of Charlotte, N. C.

CHEMISTS' CLUB.—The Chemists' Building at 50-54 East 41st St., New York City, is to be inaugurated March 17. It is intended not only to supply the social needs of the Chemists' Club, but to serve also as a meeting place for the New York section of the American Chemical Society. The Institute of Chemical Engineers, the Society of Chemical Industry, and the American Electrochemical Society will also hold meetings in the new building.

The ground floor is devoted to a public entrance hall and foyer, back of which is a large lecture room. On the next floor are the social room and restaurant of the Chemists' Club, and on the floor above this are the library, the museum and the trustees' room. The fourth and fifth floors are occupied by members' bed-rooms. The five floors constituting the upper half of the building are devoted to completely equipped laboratories for the use of analytical and consulting chemists and for investigators in pure and applied science.

The building occupies a lot 56 × 100 ft. and cost upwards of $500,000. It is owned by a stock company whose shares are held by prominent chemists and manufacturers interested in chemical industries.

The program of opening exercises will extend over three days, as follows:

March 17. In the afternoon, addresses by Edward S. Morley, Honorary President, Eighth International Congress of Applied Chemistry; Alexander Smith, President, American Chemical Society; Wm. H. Walker, President, Electrochemical Society; Prof. Wilder D. Bancroft, of Cornell University; Frank W. Clarke, U. S. Geological Survey, and R. W. Moore, President of the Chemists' Club. In the evening, scientific sessions of the New York section, American Chemical Society, with an address by the Chairman, Dr. Charles Baskerville, and the following lectures: "Rare Gases of the Atmosphere," Prof. R. B. Moore, of Butler College, Indianapolis; "Characteristics of Living Matter from the Physico-Chemical Point of View," Prof. Jacques Loeb, of the Rockefeller Institute for Medical Research.

March 18. In the forenoon, a session of the New York section, Electrochemical Society, with an address by Chairman E. A. Sperry and lectures on "Mental Catalysis," by W. R. Whitney, and "The Chemistry of Phosphorescence," by Prof. Wilder D. Bancroft, of Cornell University. At 2 p. m., the scientific portion of the program will be concluded by a session of the New York section of the Society of Chemical Industry, with an address by the chairman, Dr. Charles F. McKenna, and lectures on "The Contribution of Chemistry to Sanitation," by Prof. Wm. P. Mason, of Rensselaer Polytechnic Institute, and "The History of Chemical Industry in New York City," by Prof. Emeritus Charles F. Chandler, of Columbia University. In the evening, the Chemists' Club will hold a banquet in the new club-rooms.

March 19. A classical concert on Sunday afternoon will conclude the exercises.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—At a joint meeting with the American Society of Mechanical Engineers in New York, March 10, three papers on the cost of generating electric power were presented and discussed. Two of these, "Comments on Fixed Costs in Industrial Power Plants" and "Notes on the Cost of Electrical Energy," were presented by Mr. John C. Parker, of Rochester. The third paper was "[illegible] Industrial Power," by Mr. A. E. Hibner, of Toronto. In the first paper Mr. Parker called attention to some items which should be reckoned with in predetermining the cost of electric power, and which he claimed were not being given proper attention by engineers in making such computations. The first matter was one of capitalizing the cost of supervision. The second was one of insurance. It was claimed that where the installation of a plant increased the fire hazard on a property as a whole, the net increase of insurance cost should be assessed against the plant, together with the cost of accident and liability insurance. Mr. Parker claimed that engineers habitually underestimated the cost of borrowing money as shown in interest items. Depreciation was discussed by dividing it up into obsolescence and depreciation proper. Much was made of a so-called "marginal principle" in studying power costs. This idea was that "if part of a business's required time, material or investment which could have been utilized in some other part of the business, the cost thereof should be taken as what would have been earned in the most profitable part of the business which is capable of extension." Following this course of reasoning, it was stated that if an undertaking required $1,000, which could have been put into another part of the business to earn $300 a year, whereas it actually did earn $100, the branch drawing the money should actually be charged with the loss of profits amounting to $200 a year.

The second paper by Mr. Parker was an account of attempts to derive a general equation for the cost of power in the form: $ = A + B KW + C KW-hr. Mr. Parker was led in his attempts to derive such an equation from finding that the cost of certain kinds of machinery seemed to follow a general law somewhat similar; that is, the cost of underground distributing transformers varied according to the equation; $ = 2.75 + $5.868 × KW, and cost of overhead distribution circuits followed the equation; $ = $17.33 + $0.000577726 × circ. mils. The first trouble which was encountered was from the need of making investigation from different "planes": (1) the cost of producing energy at the station; (2) the value of the energy supplied; (3) a level of actual prices somewhere between (1) and (2). The many factors entering into the constants, A, B and C proved to be so complicated and so dependent upon local conditions of each case that the formulas amounted to little more than another way of stating already recognized guiding principles.

The third paper was one previously presented at a meeting of the Toronto Section of the American Institute. It was, in brief, a discussion of three factors involved in each industrial power problem: (1) investment charges; (2) operating charges, and (3) cost of heating. The author's argument was that the small power user, particularly, should take his problems to an independent consulting engineer before deciding whether he should build a power plant or purchase current from a supply company.

The discussion on these papers turned out to be mostly a series of arguments by supporters of central-station and isolated-plant interests in proof of the contention that one or the other system was preferable generally. Some of Mr. Parker's cost figures were criticised by the central station men and others by the isolated plant men. Mr. Arthur Williams, New York Edison Co., in commenting on depreciation, stated that very few concerns had been found to have an accumulating depreciation fund, rather preferring to charge off annually some 7½%. He placed as a third factor in depreciation the item of competition; that is, when a supply company in the field could sell current for less than what the customer could produce it, then the customer's plant had become 100% depreciated and it was economy to scrap the whole outfit. He cited several isolated plants in New York City, where central station power had been supplied at a figure which, combined with the cost of heating, was less than when isolated plants had been operated on the premises. These figures were arrived at by independent engineers called into consultation by the customer and the company. Mr. H. W. Peck, of Rochester, N. Y., called attention to the claim that necessities like heating plants need not carry a profit in figuring the cost of power as they were always needed to carry on business. He claimed that inadequacy would be found to determine obsolescence rather than any physical factors. Mr. J. H. Norris, New York, presented some figures to show that the gas-producer plant had been developed to be as satisfactory and even more reliable than a steam plant, to say nothing of the higher coal economy attainable. He cited one instance of a 35-HP. anthracite producer running a 28-HP. engine 24 hours a day for three months with only three shut-downs for cleaning the producers. The cost of power here was 0.91-ct. per KW. hr. total, including fixed charges, which were not analyzed in detail. A certain 300-HP. anthracite producer, with a gas-engine driven generator, was claimed to produce 1 KW.-hr. at a cost of 0.7 ct., including fixed charges. Three 200-HP. producers, feeding a 600-KW. engine-driven unit in 24-hour service over several months, had shown an actual total cost of 0.439 ct. per KW.-hr.

Mr. D. B. Rushmore, of Schenectady, stated that in discussing such questions it was better to divide industrial power plants into small ones and those of thousands of horse-power capacity. He called attention to the fact that the method of application of electric power to machines was very often more important in its effect on cost and quality of product of a factory than the design of the power plant or the cost of power. Mr. G. L. Fowler, of New York, made a few facetious remarks to emphasize the importance of using on the ground in making a study of the power cost in industrial plants.